Volume 15 MAY, 1941 Number 3

TOLOGY LIBRARY
Museum Library
MAY 5 1941

JOURNAL OF PALEONTOLOGY

A Publication of
The Paleontological Society
An Associate of the Geological Society of America
and
The Society of Economic Paleontologists and Mineralogists
A Division of the American Association of Petroleum Geologists

CONTENTS

Cambrian Brachiopoda from Montana ..... *W. Charles Bell* 193
Jurassic fossils from Arkansas, Louisiana, and eastern Texas ..... *Ralph W. Imlay* 256
A new coral from the Pliocene of California ..... *J. Wyatt Durham* 278
New corals: one Recent, Alaska; three Eocene, Alabama and Louisiana ..... *Thomas Wayland Vaughan* 280
Lower Cretaceous Rocky Mountain nonmarine microfossils ..... *Raymond E. Peck* 285
Oligopygus nancei, a new echinoid from Venezuela ..... *C. Wythe Cooke* 305
Two new giant Scalas from Cuba ..... *Paul Bartsch* 307
Prograngerella, a new ancestral land snail from the Upper Cretaceous of Alberta ..... *Loris S. Russell* 309
Permian pelecypods in the lower Quartermaster formation, Texas ..... *Robert Roth, Norman D. Newell and Benjamin H. Burma* 312
Leptolepis nevadensis, a new Cretaceous fish ..... *Lore David* 318
A second specimen of *Cephalaspis patteni* from the Upper Devonian of Scaumenac Bay ..... *George M. Robertson* 322
A pathologic pygidium from the Upper Cambrian of Missouri .... *Christina Lochman* 324
SOCIETY RECORDS AND ACTIVITIES
Officers, correspondents, fellows, and members of the Paleontological Society 326
Nominations for offices in the Paleontological Society for 1942 336

EDITORS

C. WYTHE COOKE, for the Paleontological Society.

NORMAN D. NEWELL, for the Society of Economic Paleontologists and Mineralogists.

The JOURNAL of PALEONTOLOGY is published bi-monthly. The numbers issued in January, May, and September are sponsored by the Paleontological Society; those issued in March, July, and November are sponsored by the Society of Economic Paleontologists and Mineralogists.

The subscription price of the JOURNAL OF PALEONTOLOGY is $6.00 per year prepaid to addresses in the United States.

Single numbers, $2.00 each.

Postage is charged extra for all other countries in the Postal Union, 40 cents on annual subscriptions (total $6.40).

The JOURNAL will furnish reprints at cost. Orders should accompany manuscript.

Communications about the JOURNAL, subscriptions, rates, memberships, change of address, and nonreceipt of preceding numbers should be addressed to Society of Economic Paleontologists and Mineralogists, P. O. Box 979, Tulsa, Oklahoma. Claims for nonreceipt of preceding numbers must be sent in within three months of the date of publication in order to be filled gratis. Communications in regard to advertising should be addressed to Norman D. Newell, University of Wisconsin, Madison, Wisconsin.

Communications in regard to manuscripts, or purely editorial matters should be addressed to Norman D. Newell, University of Wisconsin, Madison, Wisconsin, or C. Wythe Cooke, U. S. Geological Survey, Washington, D.C.

Contributors are requested to instruct their photographers to illuminate fossils from the upper left side, the conventional manner. Plates normally should be arranged for publication at the size of 5 by 7 inches, exclusive of margins, heading, and title. Printed numerals of standard size and form may be obtained free from either editor. When requesting them state number of plates and the dimensions of each plate.

Entered as second-class matter at the Post Office at Tulsa, Oklahoma, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in paragraph 4, section 538, P. L. and R., authorized April 3, 1935.

Additional entry as second-class matter at the Post Office at Menasha, Wis.

GEORGE BANTA PUBLISHING COMPANY, MENASHA, WIS.

JOURNAL OF PALEONTOLOGY

A Publication of THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS, *A Division of the American Association of Petroleum Geologists and* THE PALEONTOLOGICAL SOCIETY, *An Associate of the Geological Society of America*

VOLUME 15 MAY, 1941 No. 3

CAMBRIAN BRACHIOPODA FROM MONTANA

W. CHARLES BELL

University of Texas, Austin, Texas

ABSTRACT.—This paper brings up to date, as nearly as is practicable, the systematic paleontology of the Cambrian brachiopods of Montana; records their occurrence in measured stratigraphic sections; and assigns to their proper stratigraphic positions, so far as is possible, the collections of brachiopods from Montana listed in Walcott's "Cambrian Brachiopoda," Monograph 51 of the United States Geological Survey. Forty-five species and one variety, of which 24 species and the variety are new, belonging to 20 genera, six new, are described and illustrated. Four more or less distinct brachiopod faunas occur in the Cambrian rocks of central and southern Montana: the lowest, characterized by *Prototreta flabellata* Bell, n. sp.. is associated with the trilobite genus *Ehmania* near the base of the Middle Cambrian Meagher limestone; the next higher fauna, characterized by *Prototreta trapeza* Bell, occurs associated with the trilobite genus *Bathyuriscus*, also in the lower Meagher limestone; the next higher fauna, characterized by *Dicellomus occidentalis* Bell, n. sp., occurs associated with the Upper Cambrian trilobite genera *Cedaria* and *Crepicephalus* in the upper Park shale and lower Pilgrim limestone; and the highest fauna, characterized by *Billingsella* and *Eoorthis*, occurs in the Dry Creek shale and its partial equivalent, the Snowy Range formation. *Dicellomus* Hall is shown to possess a normal atremate ventral pseudointerarea, the "pedicle tube" described by Walcott being an accident of preservation. Species which heretofore would have been assigned to *Acrotreta* Kutorga are described under four genera proposed by the writer. The genus *Dearbornia* Walcott is rejected, the genotype and only known species being assigned to *Acrothele* Linnarsson. *Wimanella* Walcott is shown to possess a smooth shell; the new genus *Diraphora* is proposed to include those costellate species that are similar internally to *Wimanella*. Species belonging to "*Lingulella*," *Lingulepis*, "*Obolus*," and *Westonia* are not included in this report.

PURPOSE OF INVESTIGATION

THE PURPOSE of this investigation is to bring up to date, as nearly as practicable, the systematic paleontology of the Cambrian brachiopods of Montana; to record their occurrence in measured stratigraphic sections; and to assign to their proper stratigraphic position, so far as possible, the collections of brachiopods from Montana listed in Monograph 51 of the United States Geological Survey. Species belonging to "*Lingulella*," *Lingulepis*, "*Obolus*," and *Westonia* are not included in this report.

The brachipods that form the nucleus of this study were collected by field parties under the direction of Professor Charles Deiss of Montana State University during his investigations of the Cambrian stratigraphy of northwestern and south-central Montana (Deiss, 1933, 1936, 1938, 1939a). A field party from the Museum of Paleontology, University of Michigan, collected Cambrian fossils at Beartooth Butte, Republic Mountain (Cooke), Pole Creek, and Nixon Gulch under the direction of the writer. The collections made by Deiss and the writer came from measured stratigraphic sections and form the standard with which prior, unzoned collections are compared. During January and February, 1939, the writer studied collections of Cambrian brachiopods from

Montana preserved in the U. S. National Museum and has redescribed and illustrated almost all the species whose type localities are in that State.

PREVIOUS WORK ON CAMBRIAN BRACHIOPODA FROM MONTANA AND YELLOWSTONE PARK

Meek (1873) was the first to describe brachiopods from the Cambrian rocks of Montana; he assigned them to the Potsdam, or Primordial zone of Silurian age. He (1873, p. 463) suggested that a species of *Acrotreta*, should it prove distinct from *A. subconica* Kutorga, be given the name *attenuata*. Meek (1873, p. 479) also described *Iphidea?? sculptilis*, and proposed the name *Micromitra* for it in the event that it should prove to "belong to an undefined genus, either of the Brachiopoda, or of some other group."

Walcott (1897, 1898, 1905, 1908a, 1912, 1924) described 15 new species of brachiopods from the Cambrian rocks of Montana and Yellowstone Park and recorded the occurrence of 22 additional species that had previously been described from other areas. No additions of new or previously described species to the Cambrian brachiopod fauna of Montana have been published since 1924. Thus 39 species of brachiopods belonging to 17 genera had been reported from the Cambrian of Montana and Yellowstone Park at the time this study was begun.

Schuchert and Cooper (1932) and Ulrich and Cooper (1938) published revisions of several genera and species that had been reported from Montana, but dealt with no species whose type locality occurs in the Cambrian rocks there with the exception of *Wimanella simplex* Walcott.

ACKNOWLEDGMENTS

The writer is pleased to acknowledge his debt to those who have helped make this study possible. To Professor Charles Deiss of Montana State University for his loan of collections, direction and criticisms during study at the University, and continued encouragement and assistance during the later stages of the work, the writer is deeply grateful. To Dr. G. Arthur Cooper of the U. S. National Museum are due warmest thanks for his active support of the project from its beginning, assistance, advice, and criticism during its progress, and for making possible an extended visit to the Museum in 1939. Professors G. M. Ehlers and E. C. Case of the University of Michigan have given material assistance in the form of research and collecting facilities, and encouragement and kindly criticism during the preparation of the manuscript; to them the writer is glad to express his thanks.

Acknowledgments are also due Professor Charles Schuchert of Yale University, Dr. Christina Lochman of Mount Holyoke College, Professor B. F. Howell of Princeton University, and Dr. Ira Edwards of Milwaukee Public Museum for information and for permission to examine the Cambrian brachiopods in their respective institutions. Mr. M. V. Denny of the University of Michigan gave valuable advice regarding photographic problems, and John A. Wilson and Robert M. Garrels of the same institution assisted during the collecting of fossils in 1937.

The completion of the work was facilitated by University of Michigan fellowships in the department of geology for the years 1937–38 and 1938–39.

PREPARATION OF MATERIAL

Ulrich and Cooper (1938, p. 2) have given a detailed description of methods useful in disclosing the interiors of brachiopod shells, and hence only a few comments are necessary here.

The only silicified shells in the writer's collections are specimens of *Billingsella* (pl. 35, figs. 1–18), *Eoorthis* (pl. 36, figs. 14–20), and *Ocnerorthis* (pl. 37, figs. 7, 10, 11) from Crowfoot Ridge, Yellowstone Park. They are readily freed of matrix by lowering them on a monel-metal screen into a dilute solution of hydrochloric acid. The unsilicified protrematous shells were prepared either by excavating the interiors with a needle (pl. 37, fig. 9), or by stripping away the shell in order to expose an impression of the interior (pl. 34, fig. 10; pl. 36, fig. 21). Excellent impressions of muscular and pallial markings in *Billingsella* and *Eoorthis* were uncovered in this way (pl. 34, fig. 12; pl. 36, fig. 23).

The study of the atrematous and neotrematous shells presented serious difficulties, primarily because of their small size (2.0–10.0 mm. in diameter). The shell sub-

stance, perhaps originally corneous, is now composed of calcite, and inasmuch as the valves almost invariably occur in crystalline or shaly limestones, chemical methods of preparation proved unsatisfactory. Exfoliation of the shell laminae exposed internal impressions in some valves (pl. 28, fig. 31; pl. 29, figs. 18, 19; pl. 30, fig. 31; pl. 31, fig. 33), but for others, particularly the ventral valves of the acrotretids, this method failed.

Excavation of the interiors by means of a needle, although inordinately slow, yielded the best results if the valves were imbedded in only a moderately resistant matrix. The interiors of *Prototreta trapeza* Bell represent the most successful results of this method (pl. 31, figs. 38–41, 45–48). In many instances, however, the combination of a thin-shelled fossil and a very resistant limestone matrix made this method impracticable.

As a last resort, serial sections (text figs. 1, 14, 15, 18–20) revealed the presence of internal structures that could not be uncovered by any other method. A simple device, intermediate in complexity between those described by Kozlowski (1932) and Simpson (1933, 1938), enabled the writer to make oriented sections 0.1 mm. apart. A drawing of each section was made on cross-section paper with the aid of an ocular grid, and from the completed series of drawings a reasonably accurate profile of any longitudinal structure could be constructed. This method, although indispensible at times, should be avoided whenever possible because it involves destruction of specimens, and because evidence resulting from it is often open to question. When little contrast in color exists between shell substance and matrix, difficulty is experienced in making accurate drawings. Serial sectioning can demonstrate the presence of structures in a shell at the time the section is made, but the absence of structures may be the result either of their never having been developed, or of their having been lost during the process of fossilization. The atrematous and neotrematous shells are so minute that broken edges, especially in distorted shells, cannot usually be distinguished from unbroken ones. Obviously, information regarding muscular and pallial markings cannot be obtained from serial sections.

MORPHOLOGY

General Discussion

Charles D. Walcott was, without question, the foremost student of Cambrian Brachiopoda, as he was of all Cambrian faunas, during the first quarter of the present century. His monumental treatise, "Cambrian Brachiopoda," published as Monograph 51 of the U. S. Geological Survey (1912), will remain the foundation on which must be based all future studies dealing with these organisms.

References to Cambrian brachiopods since the termination of Walcott's work have for the most part been (1) investigations of a few genera by brachiopod specialists in order to determine their relationships to later stocks, and (2) proposals of new species by Cambrian students incidental to their investigation of the trilobites. Only the generic studies, which almost without exception deal with protrematous forms, have added essentially to our knowledge of the morphology and the systematic relationships of the Cambrian brachiopods. Consequently, at the time this study was begun, the state of knowledge regarding the inarticulate brachiopods was about as Walcott had left it.

The study of Cambrian stratigraphy has entered its logical second phase, that of revision of the earlier reconnaissance investigations. Trilobites, almost to the exclusion of other invertebrates, have been used for purposes of zoning and for interregional correlation. Besides being the most abundant element in most Cambrian faunas, trilobites lend themselves more readily to field determination than do the brachiopods and in the laboratory are more easily and quickly prepared for detailed study. As a result, the brachiopods have been almost entirely ignored by Cambrian workers.

The taxonomic importance of internal characters among brachiopods has been emphasized greatly by the comparatively recent studies of Buckman, Thomson, Cooper, Öpik, Kozlowski and others. Their investigations have revealed the pitfalls of homoeomorphy and polyphyletic development, pitfalls that trapped earlier workers who made identifications on the basis of external form alone. The lessons taught by these modern studies have not yet been applied to the Cambrian inarticulates, and conse-

quently the Cambrian stratigrapher is confronted by such "species" as *Iphidella pannula* and *Lingulella desiderata*, reported from Lower, Middle, and Upper Cambrian rocks and from localities as widely separated as British Columbia and Tennessee. No wonder Cambrian correlations based on evidence from brachiopods, especially the inarticulates, are regarded in some quarters as of doubtful value.

Six new genera, 24 new species, and one new variety are proposed in this paper. To some the number of new taxonomic units will seem excessive, particularly since they come from strata that have been known and studied as long as the Cambrian rocks of Montana. The writer, on the contrary, feels that he has been conservative, and that the study of better preserved and more abundant material will lead to the proposal of new species and genera that have been only hinted at in this paper. It may be that new species will be split from *Micromitra sculptilis*, *Icodonta nixonensis*, *Pegmatreta perplexa*, *Otusia sandbergi*, and *Eoorthis remnicha* as they are treated here, and that *Iphidella hexagona*, *Iphidella nyssa*, *Pegmatreta rotunda*, "*Acrotreta*" *tetonensis*, *Nisusia deissi*, and *Ocnerorthis monticola* will one day become genotypes. Whatever the verdict, it must be based on carefully prepared and abundant material from measured stratigraphic sections, probably in conjunction with additional material from regions other than Montana.

Terminology

With the exceptions discussed below, the terminology used in this paper is, for the atrematous and neotrematous brachiopods, that used by Walcott (1912, pp. 292–296), and for the protrematous forms, that used by Schuchert and Cooper (1932, pp. 6–11).

Pseudointerarea.—In their discussion of the interarea, Schuchert and Cooper (1932, p. 20) say:

> Interareas, or what were formerly called cardinal areas, are usual in most of the members of the order Protremata and especially in its most primitive stock, the Orthoidea. True interareas are at times also well developed in the Telotremata, but never in the Atremata and Neotremata. When a similar structure is present in the two last named orders it is due to holoperipheral growth or the subsequent internal thickenings of the posterior margins, and in both these instances it is termed a pseudointerarea.

The term pseudointerarea is applied by the writer to the posterior slope of the subconical ventral valve in the neotremates and in the *Micromitra-Paterina-Iphidella* group of species, and to the flattened surfaces usually characterizing the thickened posterior margins of the dorsal valve in many neotremates and both valves in the atremates. The pseudointerarea may or may not be differentiated into propareas (q.v.).

Schuchert and Cooper's (1932, p. 20) system for describing the orientation of the interarea and pseudointerarea is followed by the present writer. However, it is not clear from their discussion how the degree of proclination or hyperclination of an interarea should be described. In this paper the degree of proclination or hyperclination is read from the vertical. Thus, in a subconical ventral valve in which the posterior slope is nearly vertical, the pseudointerarea is described as being slightly procline, or the amount of proclination may be given in degrees of arc. The orthocline position is considered to be basic, and the inclination of the interarea or pseudointerarea diverges from it either in a clockwise or counterclockwise direction. Thus, in a ventral valve, as the interarea or pseudointerarea is rotated in a counterclockwise direction from the orthocline position, its orientation becomes progressively slightly apsacline, strongly apsacline, catacline, slightly procline, and, finally, strongly procline.

Proparea (*emended from Bell, 1938, p. 405*).—This term is applied to each of the two smooth subtriangular surfaces that border the delthyrium and notothyrium in many of the *Micromitra-Paterina-Iphidella* group, and which are delimited from the rest of the valve by ridges or grooves (pl. 28, figs. 3, 4, 6, 15, 25, 26). *Proparea* is also applied to each subtriangular half of the pseudointerarea, as it is developed in the neotremate dorsal and the atremate ventral valve, when the pseudointerarea is divided medially by a groove. Propareas are characteristic of the dorsal valve of certain neotremates, such as *Prototreta* (pl. 31, figs. 44–48) and *Homotreta* (pl. 30, fig. 31), and are separated by a triangular depression, which is thought to serve as a seat of muscular at-

tachment. In the linguloids and oboloids the propareas, typically developed only in the ventral valve, are separated by the pedicle groove. The term proparea is proposed for convenience in description and does not imply that the structures so designated are of similar origin.

Intertrough.—This term is proposed to designate the furrow, called "false pedicle groove" by Walcott (1912, p. 675), which characterizes the ventral pseudointerarea in certain neotremate species. The furrow, especially well developed in *Prototreta* (pl. 31, fig. 34), is deeper and wider at the commissure than at the apex of the valve. In most specimens the floor of the furrow is somewhat flattened and granular. Almost certainly the intertrough was genetically unrelated to the functional pedicle, and hence the term "false pedicle groove," which Walcott used freely but apparently never defined, seems inappropriate.

Delthyrium and notothyrium.—These terms are used for the triangular openings, serving as a passage for the pedicle, in the ventral and dorsal pseudointerareas, respectively, of the *Micromitra-Paterina-Iphidella* group of species. Inasmuch as the openings are certainly analogous and perhaps homologous to the pedicle openings in the Protremata, nothing is gained by the use of such terms as pseudodelthyrium or pedicle notch.

Homoeodeltidium and homoeochilidium.—Thomson (1927, pp. 64–68) analyzed the various usages of the terms *deltidium*, *pseudodeltidium*, and *homoeodeltidium*, and concluded that the term *homoeodeltidium*, proposed by Schuchert (in Zittel, 1913, Textbook of Paleontology, p. 358), should be applied to "a convex structure on the outer surface of the ventral valve of certain Neotremata along the area of pedicle-pressure between the apex and the pedicle-notch, not delimited from the rest of the valve by grooves." Thomson was referring to the deltidium-like plate occurring in many of the *Micromitra-Paterina-Iphidella* group, which he classified under the Neotremata. The writer follows Schuchert and Thomson in the use of *homoeodeltidium*, in place of which Walcott substituted *pseudodeltidium*, a term originally proposed by Bronn in 1862 for the single plate covering the delthyrium in the Protremata (*deltidium* of most American authors). Eventually the discordance between European and American writers in the use of *deltidium*, *pseudodeltidium*, etc. must be settled, but in this paper the writer follows Schuchert and Cooper in the protremate nomenclature. *Homoeochilidium* (*pseudochilidium* of Walcott) is used in this paper as a companion term for *homoeodeltidium* to denote the similar plate present in the dorsal valve of the *Micromitra-Paterina-Iphidella* group, this structure being analogous to the chilidium in the Protremata.

Homoeomorphy

A single instance of isochronous homoeomorphy is noted in this paper. *Prototreta flabellata* Bell, n. sp. (pl. 31, figs. 49–58) and *Homotreta interrupta* Bell, n. sp. (pl. 30, figs. 19–26) are strikingly similar externally, even to minutiae of surface ornamentation (compare pl. 30, fig. 25 with pl. 31, fig. 57). The segmentation of the fila in *Homotreta interrupta* is more commonly and more regularly developed than it is in *Prototreta flabellata*, but some valves of the two species are indistinguishable from the exterior (compare pl. 30, fig. 22 with pl. 31, figs. 53 and 55). Internally the two species are also remarkably similar but differ distinctly and consistently in the configuration of the dorsal septum (compare pl. 30, figs. 19, 26 and text fig. 1 with pl. 31, fig. 56 and text fig. 20). This difference is considered by the writer to be of generic value.

Prototreta flabellata is confined to the *Ehmania* zone of the Meagher limestone in central and south-central Montana and Yellowstone Park, and *Homotreta interrupta* is confined to the nearly contemporaneous northern phase of the Pagoda limestone, also characterized by the trilobite genus *Ehmania*, as it is developed at Lick Creek and Pentagon Mountain in northwestern Montana.

Stratigraphy

Although this paper is intended to be strictly paleontologic, the stratigraphic evidence given by the fossils not being analyzed at this time, a brief summary of the rock sequence within the Cambrian of Montana and adjacent areas to the south is necessary.

Deiss (1939a) has divided the Cambrian rocks of northwestern Montana, from the

base upward, into the Flathead sandstone, Gordon shale, Damnation limestone, Dearborn limestone, Pagoda limestone,[1] Pentagon shale, Steamboat limestone, Switchback shale, and Devils Glen dolomite. These formations are all considered to be of Middle Cambrian age. Brachiopods collected from the Gordon shale, Damnation limestone, Pagoda limestone, and Pentagon shale are discussed in this paper.

In a recent paper by Deiss (1936) the Cambrian sequence in central and south-central Montana and Yellowstone Park is given, from the base upward, as the Flathead sandstone, Wolsey shale, Meagher limestone, Park shale, Pilgrim limestone, and Dry Creek shale. The Middle-Upper Cambrian boundary has not been definitely located, but it occurs somewhere within the Park shale. The Park shale is typically barren of fossils, but at a few localities carries an Upper Cambrian fauna in its upper part. Every formation except the Flathead sandstone has yielded brachiopods discussed in this paper.

Dorf and Lochman (1940) have proposed three new formational units for the Upper Cambrian strata of southern Montana (specifically, around the Beartooth Range). These are, from the base upward, the Maurice (Dresbach equivalent), Snowy Range (Franconia equivalent), and Grove Creek (Trempealeau equivalent) formations. Brachiopods discussed in this paper were collected from the Snowy Range formation at Beartooth Butte, Republic Mountain (Cooke), and Torrey Creek.

Dorf and Lochman (1940, p. 551) would transfer the Crowfoot Ridge section (Deiss, 1936, p. 1318) from the central Montana basin to the southern Montana basin. According to them "the unit called the Pilgrim by Deiss is the Maurice formation, and that termed the Dry Creek shale apparently represents the lower portion of the Snowy Range formation."

[1] The Pagoda limestone at localities 11-2, 30-2, and 51-1 (type locality) is characterized by a *Glyphaspis* fauna; but the "Pagoda" limestone at localities 26-2, 26-3, and 28-1, where it underlies the Pentagon shale (carrying a *Bathyuriscus* fauna), is characterized by an *Ehmania* fauna. At Nixon Gulch, in south-central Montana, the *Glyphaspis* zone of the Wolsey shale underlies and is distinct from the *Ehmania* zone of the basal Meagher limestone.

REGISTER OF FOSSIL LOCALITIES

The following register gives the geographic location of the fossil localities from which the species discussed in this paper were collected and the names of the species from each locality. New species are listed without the author's name.

MONTANA STATE UNIVERSITY LOCALITIES

6. Continental Divide, Lewis and Clark Range, about 2 miles southeast of Pentagon Mountain (Deiss, 1938, p. 1075; 1939a, p. 64).
   Zone 2, Pentagon shale (type locality): 30 to 35 feet above base.
   Micromitra sculptilis (Meek)
   Pegmatreta perplexa
   Prototreta subcircularis
9. Flathead Range, on the southwest side and near the top of Pagoda Mountain (Deiss, 1939a, pp. 14, 64).
   Zone 2, Damnation limestone: lower part.
   Iphidella cf. *I. nyssa* Walcott
11. Canyon of North Fork of Dearborn River, Lewis and Clark Range, Coopers Lake quadrangle (Deiss, 1939a, pp. 33, 64).
   Zone 2, Pagoda limestone: near water level.
   Icodonta? cf. *I. nixonensis*
   Iphidella hexagona
20. Continental Divide, crest of Lewis and Clark Range, Coopers Lake quadrangle, west end of Scapegoat Basin at foot of cliffs (Deiss, 1938, p. 1087; 1939a, p. 65).
   Zone 1c, Gordon shale: about 20 feet below top.
   Wimanella simplex Walcott
   Zone 2, Damnation limestone (type locality): basal 25 feet.
   Nisusia sp. 1
   Nisusia sp. 2
23. Continental Divide, Lewis and Clark Range, south side of Bench Mark 8105 Peak, head of Ahorn Creek, Ovando quadrangle (Deiss, 1939a, p. 65).
   Zone 1, Gordon shale: upper part.
   Iphidella nyssa Walcott
   Wimanella simplex Walcott
26. Continental Divide, Lewis and Clark Range, above head of south fork of

Lick Creek (Deiss, 1939a, pp. 16, 17, 66).

Zone 2, "Pagoda" limestone: 52 feet below top.

Homotreta interrupta
Pegmatreta perplexa
Pegmatreta rotunda

Zone 3, "Pagoda" limestone: 35 feet above zone 2.

Homotreta interrupta
Micromitra sculptilis (Meek)
Pegmatreta perplexa
Pegmatreta rotunda

Zone 4, Pentagon shale: 34 feet above base.

Acrothele pentagonensis
Micromitra sculptilis (Meek)
Micromitra? subdita
Pegmatreta perplexa
Prototreta subcircularis
Prototreta trapeza Bell

Zone "loose," Pentagon shale: specimens restricted to lower half of formation, but exact stratigraphic horizon unknown.

Nisusia lickensis

Zone "top," Pentagon shale: 110 feet above zone 4. Fossils collected in place, but from an interval 45 feet thick.

Prototreta cf. *P. trapeza* Bell
Nisusia lickensis

28. Lewis and Clark Range, ridge between Rock and Baldy Bear Creeks (Deiss, 1939a, pp. 19, 66).

Zone 1, "Pagoda" limestone: 41 feet below top.

Homotreta interrupta
Nisusia deissi

Zone "loose," "Pagoda" limestone: specimens not collected in place, but restricted to within 20 feet stratigraphically above zone 1.

Micromitra cf. *M. sculptilis* (Meek)
Nisusia montanaensis

30. Continental Divide, Lewis and Clark Range, Chinese Wall, Cliff Mountain (Deiss, 1939a, pp. 22, 67).

Zone 2, Pagoda limestone.

Iphidella hexagona

31. Little Belt Mountains, Belt Creek valley, gulch half a mile east of Hoover Creek (Deiss, 1936, p. 1271).

Zone 1, Wolsey shale: thin limestones interbedded in upper part.

Nisusia cf. *N. deissi*

32. Little Belt Mountains, north side of Belt Creek valley, 3 to 5 miles southeast of Monarch (Deiss, 1936, p. 1269).

Zone 3, Pilgrim limestone: lower part.

Dicellomus occidentalis

33. Little Belt Mountains, south end of Keegan Butte in Belt Park on south side of Belt Creek, about 2 miles east of Monarch (Deiss, 1936, p. 1274).

Zone 1, Pilgrim limestone: about 33 feet below top.

Dicellomus cf. *D. occidentalis*

Zone 2, Pilgrim limestone: basal few feet.

Dicellomus occidentalis

Zone 3, Wolsey shale: interbedded lenticular limestone from lower (L) and upper (U) parts of shale slope.

Icodonta typica

34. Little Belt Mountains, South Hill, immediately south of Keegan Butte (Deiss, 1936, p. 1276).

Zone 5U, Wolsey shale: interbedded lenticular limestone from upper part of shale slope.

Micromitra sculptilis (Meek)
Nisusia cf. *N. deissi*

38. Little Belt Mountains, north slope of Dry Wolf Creek valley, about 2 miles above its junction with Lion Gulch (Deiss, 1936, p. 1279).

Zone 1, Park shale: limestone lenses throughout upper 175 feet.

Dicellomus occidentalis

Zone 3, Pilgrim limestone: about 300 feet above base.

Dicellomus occidentalis

Zone 4, Pilgrim limestone: about 20 feet above zone 3.

Dicellomus sp.

Zone 5, Pilgrim limestone: about 20 feet above zone 4.

Dicellomus sp.

39. Little Belt Mountains, north side of Yogo Gulch immediately west of the mouth of Bear Creek (Deiss, 1936, p. 1283).

Zone 1, Dry Creek shale: about 10 feet above base.

Eoorthis cf. *E. remnicha* (Winchell)

40. Big Snowy Mountains, head of Swimming Woman Creek (Deiss, 1936, p. 1290).

Zone 2, Wolsey shale: about 120 feet above base.

Icodonta nixonensis
Wimanella aurialis

41. Big Snowy Mountains, head of Swimming Woman Creek (Deiss, 1936, p. 1290).

Zone 3, Park shale: about 30 feet below top.

Dicellomus occidentalis

42. Castle Mountains, north side of Checkerboard Creek (Deiss, 1936, p. 1286).

Zone 2, Meagher limestone: about 50 feet above base.

Schuchertina cf. *S. cambria* Walcott

43. Gallatin Range, northwest spur of Crowfoot Ridge, Yellowstone National Park (Deiss, 1936, p. 1318).

Zone 3, Meagher limestone: *Ehmania* zone, about 37 feet above base.

Nisusia deissi

Zone 3a, Meagher limestone: limestone nodules in 3–5 ft. shale bed, immediately overlying zone 3.

Prototreta flabellata

44. Gallatin Range, northwest spur of Crowfoot Ridge, Yellowstone National Park (Deiss, 1936, p. 1318)

Zone 2, Dry Creek shale: upper 60 feet.

"Acrotreta" tetonensis Walcott
Billingsella cf. *B. alata*
Billingsella exasperata
Billingsella perfecta Ulrich and Cooper
Billingsella perfecta pyriformis
Billingsella radiata
Dicellomus mosaica
Eoorthis remnicha (Winchell)
Linnarssonella elongata
Ocnerorthis monticola

45. Horseshoe Hills, on both sides of Nixon Gulch, about 6 miles north of Manhattan, Three Forks quadrangle (Deiss, 1936, p. 1311).

Zone 1, Wolsey shale: middle part of chocolate and green shale on Trilobite Hill (equivalent of Mich. M4-1 and M4-2).

Icodonta nixonensis
Wimanella aurialis

Zone 2, Meagher limestone: *Ehmania* zone, at base of formation, on Trilobite Hill (equivalent of Mich. M4-3).

Micromitra sculptilis (Meek)
Prototreta flabellata

Zone 3; Meagher limestone: *Bathyuriscus* zone, 20 feet above zone 2, on Trilobite Hill (equivalent of Mich. M4-4).

Micromitra sculptilis (Meek)
Micromitra? subdita
Pegmatreta perplexa
Prototreta subcircularis
Prototreta trapeza Bell

Zone 3a, Meagher limestone: *Bathyuriscus* zone, 1500 feet N. 12° W. from zone 3 (equivalent of Mich. M4-4a and U.S.N.M. loc. 19z).

Same fauna as zone 3.

46. Horseshoe Hills, on both sides of Nixon Gulch, about 7 miles north of Manhattan, Three Forks quadrangle (Deiss, 1936, p. 1311).

Zone 3, Dry Creek shale: about 20 feet above base.

"Acrotreta" tetonensis Walcott
Billingsella alata
Billingsella cf. *B. exasperata*
Billingsella perfecta Ulrich and Cooper
Billingsella plicatella Walcott
Ceratreta hebes
Dicellomus mosaica
Eoorthis remnicha (Winchell)
Huenella abnormis (Walcott)
Otusia sandbergi (Winchell)

47. Big Belt Mountains, north side of Beaver Creek, opposite schoolhouse about 2 miles downstream from Nelson (Deiss, 1936, p. 1295).

Zone 2, Meagher limestone: basal bed lying on Wolsey shale.

Diraphora? sp.

Zone 2T, Meagher limestone: fossiliferous bed 8 feet above zone 2.

Micromitra sculptilis (Meek)

Zone 3, Meagher limestone: ½ to 2 inch layer of black fissile shale, 3 feet above zone 2T, with intercalated limestone nodules.

Micromitra cf. *M. sculptilis* (Meek)
Pegmatreta perplexa
Prototreta mimica

Zone 3 "loose," lower Meagher limestone talus.

Prototreta trapeza Bell

51. Prairie Reef Mountain, Lewis and Clark Range, southeastern part of Silvertip quadrangle (Deiss, 1938, p. 1080; 1939a, p. 67).

Zone 1, Pagoda limestone (type locality): about 100 feet above base.

Iphidella hexagona

53. Kid Mountain, Swan Range, between Gordon and Youngs Creeks Ovando quadrangle (Deiss, 1939a, pp. 10, 68).

Zone 1, Gordon shale: about 70 feet below top.

Iphidella nyssa Walcott
Wimanella cf. *W. simplex* Walcott

University of Michigan Localities

M1. East face of Beartooth Butte, Beartooth Mountains, Wyoming, below north end of Bighorn dolomite cliffs (Dorf, 1934, pp. 721–726).

Zone 4, Snowy Range formation: *Conaspis* zone, in lower third of formation and immediately overlying *Collenia magna* zone (Fenton, 1939, p. 97).

"Acrotreta" tetonensis Walcott
Billingsella alata
Billingsella exasperata
Billingsella perfecta Ulrich and Cooper
Billingsella radiata
Ceratreta hebes
Dicellomus mosaica
Eoorthis remnicha (Winchell)
Linnarssonella elongata
Otusia sandbergi (Winchell)

M2. Northeast nose of Republic Mountain, above old Republic smelter, Cooke, Montana (Lovering, 1929, p. 23).

Zone 1, Snowy Range formation: *Conaspis* zone, immediately overlying *Collenia magna* zone.

Billingsella perfecta Ulrich and Cooper
Billingsella plicatella Walcott
Billingsella radiata
Ceratreta hebes
Dicellomus mosaica
Eoorthis remnicha (Winchell)

M3. North slope of Pole Creek valley, about 1.5 miles upstream from its junction with Cherry Creek, Three Forks quadrangle.

Zone 1, Meagher limestone: a 13-ft. interval of platy and nodular limestone, 40 feet above base of formation; part of *Ehmania* zone (equivalent of U.S.N.M. loc. 20k).

Iphidella hexagona
Micromitra sculptilis (Meek)
Nisusia deissi
Nisusia montanaensis

Zone 2, Meagher limestone: a 13-ft. interval of fissile black shale with intercalated limestone nodules, about 68 feet above base of formation; part of *Ehmania* zone.

Micromitra sculptilis (Meek)
Prototreta flabellata

M4. Same as Montana locality 45.

Zone 1, Wolsey shale: lower or *Zacanthoides* zone of Mont. loc. 45-1.

Icodonta nixonensis

Zone 3, Meagher limestone: equivalent of Mont. loc. 45-2.

Micromitra sculptilis (Meek)
Prototreta flabellata

Zone 4, Meagher limestone: equivalent of Mont. loc. 45-3.

Micromitra sculptilis (Meek)
Micromitra? subdita
Pegmatreta perplexa
Prototreta subcircularis
Prototreta trapeza Bell

Zone 4a, Meagher limestone: equivalent of Mont. loc. 45-3a and U.S.N.M. loc. 19z.

Same fauna as zone 4.

U.S. NATIONAL MUSEUM LOCALITIES[2]

4e. Dry Creek shale: head of Jackson

[2] See U. S. Geol. Survey, Mon. 51, pp. 160–291 for detailed descriptions of localities.

Creek, Teton Mountains, Grand Teton quadrangle, Uinta County, Wyoming.

"Acrotreta" tetonensis Walcott
Billingsella perfecta Ulrich and Cooper

4h. Meagher limestone: 4 miles east-northeast of Logan, Three Forks quadrangle.

Micromitra sculptilis (Meek)

4j. Dry Creek shale: head of Deep Creek, Canyon quadrangle, Yellowstone Park.

Billingsella alata
Billingsella exasperata
Billingsella plicatella Walcott
Huenella abnormis (Walcott)

4n. Meagher limestone (*Ehmania* zone): head of Jackson Creek, Teton Mountains, Grand Teton quadrangle, Uinta County, Wyoming.

Prototreta flabellata

4o. Meagher limestone (*Bathyuriscus* zone): head of Jackson Creek, Teton Mountains, Grand Teton quadrangle Uinta County, Wyoming.

Prototreta trapeza Bell

4p. Meagher limestone: 2 miles northeast of Logan, Three Forks quadrangle.

Micromitra cf. *M. sculptilis* (Meek)

4q. Gordon shale: ridge between Gordon and Youngs Creeks, Ovando quadrangle.

Acrothele colleni Walcott
Iphidella nyssa Walcott
Wimanella simplex Walcott

4r. Dry Creek shale: 3 miles north-northeast of Mount Delano, Livingston quadrangle.

Eoorthis remnicha (Winchell)

4v. Gordon shale: Gordon Creek, 6 miles from South Fork of Flathead River, Ovando quadrangle.

Acrothele panderi Walcott
Iphidella nyssa Walcott
Wimanella simplex Walcott

4w. Gordon shale: Youngs Creek, 5 miles from its junction with Danaher Creek, Ovando quadrangle.

Wimanella simplex Walcott

4x. Wolsey shale (interbedded limestone): base of butte in Belt Park, about 6 miles northwest of Neihart, Little Belt Mountains quadrangle.

Micromitra sculptilis (Meek)

5f. Wolsey shale (interbedded limestone): head of Sawmill Creek, 11 miles south of Neihart, Little Belt Mountains quadrangle.

Micromitra sculptilis (Meek)
Nisusia cf. *N. deissi*

5j. Gordon shale: about 6 miles west-northwest of Scapegoat Mountain, Coopers Lake quadrangle.

Acrothele panderi Walcott

5k. (1) Meagher limestone, and (2) limestone lenses in Park shale: head of Sawmill Creek, 8 miles south of Neihart, Little Belt Mountains quadrangle. (Original label gives 13 miles south of Neihart).

(1) *Micromitra sculptilis* (Meek)
(1) *Nisusia* cf. *N. deissi*
(1) *Schuchertina cambria* Walcott
(2) *Dicellomus occidentalis*

9h. Meagher limestone (*Ehmania* zone): Beaver Creek, 5 miles north of York, Big Belt Mountains, Fort Logan quadrangle.

Diraphora? sp.
Micromitra sculptilis (Meek)
Prototreta flabellata

9k. Middle Cambrian: limestone forming 1c of the Dearborn River section (Walcott, 1908b, p. 201), on North Fork of Dearborn River, in the eastern part of the Lewis and Clark National Forest, Lewis and Clark County. (Stratigraphic position unknown; possibly Damnation limestone.)

Acrothele clarki (Walcott)

19z. Meagher limestone (*Bathyuriscus* zone): Nixon Gulch, Three Forks quadrangle (equivalent of Mont. 45-3a and Mich. M4-4a).

Prototreta trapeza Bell

20k. Meagher limestone (*Ehmania* zone): Pole Creek, Three Forks quadrangle (equivalent of Mich. M3-1).

Iphidella hexagona
Nisusia deissi
Nisusia montanaensis

54z. Wolsey shale: Big Snowy Mountains (probably equivalent of Mont. 40-2).

Wimanella aurialis

62r. Dry Creek shale: Abiather Mountain, Yellowstone Park.
Billingsella exasperata
Billingsella perfecta Ulrich and Cooper

147a. Dry Creek shale: Spring Hill Canyon, west side of Bridger Range, Gallatin County.
Billingsella exasperata

149a. Meagher limestone: forks of Pole Creek, above Cherry Creek basin, Three Forks quadrangle.
Diraphora striata (Walcott)
Iphidella cf. *I. hexagona*

150a. Dry Creek shale: about 5 miles north of Hillsdale, Three Forks quadrangle.
Billingsella exasperata
Billingsella plicatella Walcott

151. Dry Creek shale: point overlooking Churn Canyon, west side of Bridger Range, Gallvatin County.
Billingsella exasperata
Billingsella plicatella Walcott
Eoorthis remnicha (Winchell)

151a. Dry Creek shale: point overlooking Churn Canyon, west side of Bridger Range, Gallatin County.
Billingsella cf. *B. plicatella* Walcott
Dicellomus mosaica

151e. Dry Creek shale: Soda Butte Creek, Yellowstone Park.
Billingsella perfecta Ulrich and Cooper

152. Dry Creek shale: ridge between Churn and Cottonwood Canyons, west side of Bridger Range, Gallatin County.
Billingsella exasperata
Billingsella plicatella Walcott
Eoorthis remnicha (Winchell)

152a. Dry Creek shale: west side of Dry Creek, below Pass Creek, Three Forks quadrangle.
Dicellomus mosaica

153. Dry Creek shale: 5 miles north of Hillsdale, Three Forks quadrangle.
Billingsella plicatella Walcott
Huenella abnormis (Walcott)

153a. Dry Creek shale: about 5 miles north of Hillsdale, Three Forks quadrangle.
Billingsella cf. *B. plicatella* Walcott
Eoorthis remnicha (Winchell)

154. Dry Creek shale: about 5 miles north of Hillsdale, Three Forks quadrangle.
Billingsella perfecta Ulrich and Cooper
Billingsella plicatella Walcott
Eoorthis remnicha (Winchell)

155a. Meagher limestone (*Bathyuriscus* zone): near Hillsdale, Three Forks quadrangle.
Micromitra sculptilis (Meek)
Micromitra? subdita

156a. Meagher limestone (*Ehmania* zone): near Hillsdale, Three Forks quadrangle.
Prototreta flabellata

156b. Dry Creek shale: north end of Gallatin Valley, Three Forks quadrangle.
Billingsella plicatella Walcott

157. Dry Creek shale: near Hillsdale, Three Forks quadrangle.
Billingsella plicatella Walcott
Huenella abnormis (Walcott)

158. Dry Creek shale: near Hillsdale, Three Forks quadrangle.
Billingsella exasperata
Billingsella plicatella Walcott
Dicellomus mosaica
Eoorthis remnicha (Winchell)
Huenella abnormis (Walcott)

159. Meagher limestone (*Ehmania* zone): north of West Gallatin (Gallatin) River, Gallatin County.
Diraphora? sp.
Micromitra sculptilis (Meek)
Nisusia cf. *N. montanaensis*
Prototreta flabellata

302. Meagher limestone (*Ehmania* zone?): east of West Gallatin (Gallatin) River, above Gallatin, Gallatin County.
Micromitra sculptilis (Meek)
Prototreta attenuata (Meek)

302b. (1) Meagher limestone and (2) Dry Creek shale: near Crowfoot Ridge, Gallatin quadrangle, Yellowstone Park.
(1) *Micromitra sculptilis* (Meek)
(2) *Eoorthis remnicha* (Winchell)

302c. Dry Creek shale: south side of Galatin Valley, Yellowstone Park.
Ocnerorthis? iddingsi (Walcott)

302f. Dry Creek shale: north side of Elk Pass, between Buffalo and Slough Creeks, Yellowstone Park.

Billingsella exasperata
Eoorthis remnicha (Winchell)
Otusia sandbergi (Winchell)

302g. Dry Creek shale: north slope of Crowfoot Ridge, Gallatin quadrangle, Yellowstone Park.
Billingsella cf. *B. exasperata*
Billingsella perfecta Ulrich and Cooper
Billingsella perfecta pyriformis
Billingsella weedi (Walcott)
Huenella abnormis (Walcott)

302k. Limestone in upper Park shale (?): near Gallatin, Three Forks quadrangle.
Dicellomus occidentalis

302n. Dry Creek shale: south side of Gallatin Valley, Gallatin County.
Eoorthis remnicha (Winchell)

302r. Dry Creek shale: near Princeton, Philipsburg quadrangle.
Billingsella cf. *B. exasperata*
Billingsella cf. *B. plicatella* Walcott

302t. Meagher limestone: northeast of Logan, Three Forks quadrangle.
Micromitra sculptilis (Meek)

302w. Dry Creek shale: Madison Mountain, Montana.
"*Acrotreta*" *tetonensis* Walcott

SYSTEMATIC DESCRIPTIONS[3]

The classification of the Cambrian Brachiopoda, especially of the Gastrocaulia (Atremata and Neotremata), is at present in a state of uncertainty and fluctuation. Rather than to place genera in families whose limits are very inadequately known, or to propose systematic divisions on the basis of the scattered information derived from the present study, the writer has introduced no taxonomic units of higher rank than genera. The arrangement of genera follows that of Schuchert and LeVene (1929) as closely as is feasible.

[3] The catalogued specimens referred to in the following descriptions and in the descriptions of plates are preserved at Montana State University (designated "Mont."), the University of Michigan (designated "Mich."), and the United States National Museum (designated "U.S.N.M."). Binary fossil locality designations 6-2 to 53-1 refer to Montana State University localities, binaries M1-4 to M4-4a refer to University of Michigan localities, and United States National Museum localities are designated "U.S.N.M."

Genus MICROMITRA Meek, 1873

A group of more or less closely related species is at present assigned to *Micromitra* Meek, *Paterina* Beecher, and *Iphidella* Walcott. Its members are characterized by a moderately to strongly convex ventral valve, a strongly apsacline to procline ventral pseudointerarea, and, especially, by a minute to large homoeodeltidium. Walcott (1912, p. 336) considered *Paterina* and *Iphidella* to be subgenera of *Micromitra*. He assigned to *Paterina* the species "whose surface is formed of simple concentric striae and lines of growth"; to *Iphidella* those "whose surface is formed by the union of the crenulated striae so as to form a fine network of obliquely arranged lines;" and to *Micromitra* those "with the intermediate type of surface."

The present writer is convinced that some, if not all, of these genera are polyphyletic, and that the type of surface ornamentation cannot be used alone as a criterion for generic separation. As conceived in this paper the species *Micromitra sculptilis* (Meek) contains specimens possessing surface patterns assignable to all three genera as defined by Walcott. Indeed, Walcott himself, in discussing varieties of *Micromitra* (*Iphidella*) *pannula* (White), figured specimens from near Ophir, Utah, which he said (Walcott, 1912, p. 363) "illustrate the entire evolution of the '*pannula*' type of surface from the concentric striae to the fine network of oblique, raised lines dividing the surface into minute, diamond-shaped depressions."

So far as the writer is aware, no conclusive proof has yet been offered to support the belief that *Paterina* is characterized by a homoeodeltidium. Walcott (1912, pl. 2, fig. 3c) illustrated a cross section of a specimen of *Paterina labradorica swantonensis* (Walcott), which purports to demonstrate the presence of the homoeodeltidium. However, the section is not cut along the longitudinal axis of the ventral valve, and the "pseudodeltidium" is merely the strongly curved posterolateral margin of the shell. It should be noted that the shells of *Paterina labradorica* (Billings) and *Paterina labradorica swantonensis* (Walcott) are built up of successive laminae, a condition not observed by the writer in any of the western species assigned at present to *Paterina*.

Walcott (1912, p. 322) classified *Paterina* under the Atremata. Thomson (1927, p. 116) included it in the Neotremata on the basis of holoperipheral growth. Schuchert (in Schuchert and LeVene, 1929) accepted Thomson's new order Palaeotremata, included *Paterina* in it, and placed *Micromitra* and *Iphidella* in the Atremata. The present writer believes that *Micromitra* and *Iphidella* fit best into the Atremata of the prevailing classification; that in the future a new order will be proposed to contain them, together with new genera based on species now assigned to *Micromitra*, *Paterina*, and *Iphidella;* and that *Paterina* s.s. must be restudied before it can be correctly placed in any classification.

Unfortunately an exhaustive study of *Micromitra* and the related genera (subgenera of Walcott) *Paterina* and *Iphidella* cannot be undertaken at this time. Any comprehensive treatment must involve new collections and many difficult preparations to disclose internal morphology, shell structure, and details of the pseudointerarea in all species now assigned to the three genera. Such a study must be left to the future, and the writer can only contribute here information regarding *Micromitra sculptilis* (Meek), the genotype, and related species occurring with it in Montana.

MICROMITRA SCULPTILIS (Meek)
Plate 28, figures 1–26

Iphidea?? sculptilis MEEK, *1873*, U. S. Geol. and Geog. Survey Terr., Sixth Ann. Rept., p. 479.

Kutorgina sculptilis WALCOTT (part), *1884*, U. S. Geol. Survey, Mon. 8, p. 20, pl. 1, figs. 7, 7a (not pl. 1, fig. 7b; pl. 9, fig. 7).

Iphidea sculptilis WALCOTT, *1899*, U. S. Geol. Survey, Mon. 32, pt. 2, pl. 60, figs. 5, 5a–c.

Micromitra sculptilis WALCOTT (part), *1912*, U. S. Geol. Survey, Mon. 51, p. 341, pl. 3, figs. 5, 5a, 5e (not figs. 5b–d).

Iphidea pealei WALCOTT (part), *1897*, U. S. Nat. Mus., Proc., vol. 19, p. 712, pl. 59, figs. 3, 3a–b (not fig. 3c).

Micromitra pealei WALCOTT (part), *1912*, U. S. Geol. Survey, Mon. 51, p. 339, pl. 3, figs. 3, 3a–b, 3d–e (not fig. 3c).

Outline transversely subelliptical except for truncated posterior margin with elevated ventral apex projecting slightly beyond it; line of valve junction slightly shorter than greatest width of shell; surface ornamentation basically a rectangular pattern formed by junction of fila and radiating ribs or ridges, often greatly modified in younger portions of shell; shell calcareocorneous, composed of a single homogeneous layer, usually thin.

Ventral valve: Profile obtusely triangular, highest point being at umbo vertically above or slightly anterior to line of valve junction; apex sharply pointed, formed of smooth tip with a pair of low callosities anterolateral to it, strongly incurved over homoeodeltidium; propareas flat, smooth or granular, unstriated; delthyrium high, triangular; delthyrial angle 70°–90°; homoeodeltidium thin, strongly convex, smooth or granular, rising abruptly and continuously from propareas, and more or less completely filling delthyrium. Interior without markings other than reflection of fila and radiating ridges; pair of small projecting knobs of unknown function bordering apex of delthyrium (pl. 28, fig. 13).

Dorsal valve: Profile slightly and more or less evenly convex; apex broadly rounded, slightly incurved over homoeochilidium, carrying a low smooth callosity, which extends anteriorly into four symmetrically arranged lobes, of which the middle two are most prominent; propareas flat, smooth or granular, sometimes crossed parallel to posterior margin by a few lines or low ridges, which are not continuous with fila (pl. 28, figs. 25, 26); notothyrium low, obtusely triangular, more or less completely filled by thin convex homochilidium, which rises smoothly and continuously from propareas. Interior without markings other than reflection of fila and radiating ridges.

	Dimensions (mm.) Length	Width	Height	L/W	H/W
Ventral valves:					
U.S.N.M. 7864a	2.2?	2.7	1.1?	0.81	0.41
U.S.N.M. 26430a	3.8?	4.8	2.0	0.80	0.42
Mont. T1205a	3.2	3.5	1.4?	0.91	0.40
Mich. 20814a	1.8	2.1	1.0	0.86	0.48
Dorsal valves:					
Mont. T1203b	5.1	7.0?		0.73	
Mont. T1203c	5.0	7.5		0.67	

Holotype, U.S.N.M. 7864a; hypotypes, U.S.N.M. 3467a, 26430a; Mont. T1203a–d, T1204a, T1205a–b, T1206a–d, T1207a, T1208a; Mich. 20813a, 20814a, 20818a.

Horizon and locality.—Middle Cambrian. "Pagoda" limestone: 26–3, Lick Creek; 28, loose (?), Rock-Baldy Bear Creek ridge. Pentagon shale: 6–2, Pentagon Mountain; 26–4, Lick Creek. Meagher limestone (*Ehmania* zone): 45–2, M4–3, Nixon Gulch; M3–1, M3–2, Pole Creek. Meagher limestone (*Bathyuriscus* zone): 45–3, 45–3a M4–4, M4–4a, Nixon Gulch. Lower Meagher limestone: 47–2T, 47–3 (?), Beaver Creek. Limestone lenses in upper Wolsey shale: 34–5U, South Hill. U.S.N.M. localities: Meagher limestone: 4h, 4p (?), 159, *302*,[4] 302t, *near Logan;* 155a, near Hillsdale 302b (1), near Crowfoot Ridge; 9h, Beaver Creek; 5k (1), head of Sawmill Creek. Limestone lenses in Wolsey shale: 4x, Belt Park; 5f, head of Sawmill Creek.

Distinguishing characters.—*Micromitra sculptilis* is characterized by a calcareocorneous shell composed of a single layer; a thin, convex homoeodeltidium, which is continuous with the propareas and usually covers most of the delthyrium; and a surface ornamentation that is basically a rectangular pattern resulting from the junction of fila and radiating ribs or ridges, but which may be greatly modified in younger portions of the shell.

Discussion.—An analysis of Walcott's latest (1912, pp. 339, 341) opinions regarding *M. sculptilis* and *M. pealei* reveals several inconsistencies. He does not refer to *M. pealei* in his discussion of *M. sculptilis*, but says that a

> study of the specimens of *M. sculptilis* collected from the same horizon, at a point not far distant from the original locality, shows the presence of a false area and a pseudodeltidium (homoeodeltidium) of the same type as that of *M.* (*Paterina*) *bella* (Billings).

Thus Walcott implies the presence in *M. sculptilis* of a large homoeodeltidium covering most of the delthyrium. However, in the next paragraph he writes:

> The most nearly related species is *M. haydeni* Walcott, which has a similar surface, but the latter has a large pseudodeltidium (homoeodeltidium) on the ventral valve.

[4] Type locality in italics.

Here he apparently implies a small homoeodeltidium in *M. sculptilis*. The holotype (pl. 28, figs. 5, 11) of *M. sculptilis* has the apex broken, so that all references to a homoeodeltidium must be based on other specimens conspecific with it.

Walcott (1912, p. 339) wrote, in his discussion of *M. pealei:*

> This species approaches *M. sculptilis* (Meek) in some examples of the ventral valve. It differs mainly in the narrow pseudodeltidium and the character of the surface markings.

Whether Walcott meant that *M. sculptilis* has no homoeodeltidium, or that the homoeodeltidium is present but different from that in *M. pealei*, is not clear.

Walcott (1912, p. 339) was in error when he stated in his description of *M. pealei* that

> The striae of growth cross the false area and arch over the delthyrium (homoeodeltidium?).

Both the ventral and dorsal propareas are distinctly separated from the filate and radially ribbed portion of the shell by a distinct ridge formed by the apical flexing and fusion of the fila (pl. 28, figs. 1–6, 15, 20, 25, 26). The propareas are smooth or somewhat granular, and continuous with the convex homoeodeltidium and homoeochilidium. Rarely the propareas bear short, scattered, horizontal ridges, which are not continuous with the fila.

The petaloid callosity (pl. 28, figs. 16, 21, 25) on the dorsal apex of *M. sculptilis* has not before been described. It is low and smooth, and its anterior margin is deeply scalloped into four lobes, the middle two of which are the largest. The first discernible filum closely parallels the scalloped margin of the callosity.

The surface ornamentation of *M. sculptilis* is extremely varied in its expression. The basic pattern, always visible on the apical portion of the shell, consists of rectangles formed by the intersection of the fila and radiating ribs. The fila flex toward the apex at their junction with the radiating ribs, forming a scalloped pattern. On many shells, particularly those from the lower or *Ehmania* zone of the Meagher limestone, the rectangular pattern is clearly defined over the entire surface (pl. 28, figs. 7–9, 11, 20). On many others, however, various modifications of the rectangular pattern occur on the

younger portion of the shell. The radiating ribs may almost disappear anteriorly, leaving only the regular fila (pl. 28, figs. 16, 18). A second variation (pl. 28, figs. 23–24), common on specimens from the *Bathyuriscus* zone of the Meagher limestone, is characterized by numerous radiating ridges, rather than ribs, apparently developed from the fusion of segmented fila. In this pattern the segments of fila project laterally from the radiating ridges, alternating in position with the projecting segments of fila composing the adjacent radial ridge. A third variation (pl. 28, figs. 6, 12), most common among valves from the *Ehmania* zone, is characterized by a complex pattern resulting partly from a secondary quincunxial arrangement of ribs, and partly from the change of the rectangles to circular pits. Each of the four types of surface pattern appears to be most characteristic of either the *Ehmania* or *Bathyuriscus* zone or their equivalents in northwestern Montana, but all variations are present in each zone, as well as transitional forms between them. Although the writer has had at his disposal large collections of *M. sculptilis* from Montana, he has been unable to find that any of the variations in surface pattern has either stratigraphic or geographic value and has therefore refrained from distinguishing them by name.

Because the present study has revealed wide and inconsistent variations in surface ornamentation among shells otherwise identical with the holotype of *Micromitra sculptilis* (Meek), and because the range of variation includes well within it the types of ornamentation on the holotypes of *M. sculptilis* (pl. 28, figs. 5, 11) and *M. pealei* (pl. 28, figs. 4, 10), and, finally, because the type localities of the two described species are, so far as can be determined, only a few miles apart, the writer feels that *M. sculptilis* and *M. pealei* are merely slightly different members of an extremely variable species, and that present knowledge does not warrant their designation by different names.

MICROMITRA? SUBDITA Bell, n. sp.
Plate 28, figures 27–30

Micromitra pealei WALCOTT (part), *1897*, U. S. Nat. Mus., Proc., vol. 19, pl. 59, fig. 3c;—— (part), *1912*, U. S. Geol. Survey, Mon. 51, pl. 3, fig. 3c.

Outline transversely subelliptical except for truncated posterior margin, with elevated ventral apex projecting slightly beyond it; line of valve junction slightly shorter than greatest width of shell; concentric surface undulations broad, low, irregularly spaced, curving slightly toward apex at junction with regularly spaced, broad, shallow radiating grooves, and thickened and bent abruptly toward apex on margins of delthyrium and notothyrium; shell thin, dark-brown or black, extremely glossy, calcareocorneous, composed of a single layer.

Ventral valve: Profile probably subtriangular, with apex incurved over posterior margin; delthyrium apparently a broad triangular gape below apex; propareas not observed. Interior unknown.

Dorsal valve: Profile slightly convex, greatest height at umbo of broadly rounded, slightly incurved marginal apex; petaloid callosity faintly visible on apex of holotype, but exact characteristics indeterminable; notothyrium low, widely triangular; notothyrial angle 135°; propareas not observed. Central portion of valve strongly thickened internally; two narrow, high ridges originate slightly forward of an apical depression or pit and diverge anteriorly at an angle of 40°; low, narrow longitudinal ridge midway between them; no muscular impressions observed.

Dimensions (mm.)

	Length	Width	L/W
Ventral valve:			
Mont. T1211b....	2.8?	3.5?	0.80
Dorsal valve:			
Mont. T1211a....	3.4?	5.0?	0.68

Holotype, Mont. T1211a; paratype, Mont. T1211b; figured specimen, Mich. 20815a.

Horizon and Locality.—Middle Cambrian. Pentagon shale: *26–4, Lick Creek.* Meagher limestone (*Bathyuriscus* zone): 45–3, 45–3a, M4–4, M4–4a, Nixon Gulch. Meagher limestone: U.S.N.M. loc. 155a, near Hillsdale.

Distinguishing characters.—This species is best characterized by its dark brown to black, extremely glossy shell and by its surface ornamentation composed of low concentric ridges, slightly scalloped between intersections with faint radiating grooves. The writer knows of no described species with which it might be confused.

Discussion.—The character of the homoeodeltidium, if present, could not be deter-

mined from the available crushed specimens, nor could it be definitely ascertained whether or not propareas were present. Although the assignment of this species to *Micromitra* must be tentative until more completely preserved ventral valves are known, this species appears to be congeneric with *Micromitra sculptilis* in form, shell structure, and the presence of a low petaloid callosity at the dorsal apex. No interpretation of the internal structures in the holotype is attempted.

Genus IPHIDELLA Walcott, 1905

Walcott (1912, p. 336) distinguished the subgenus *Iphidella* from *Micromitra* and *Pa-*

EXPLANATION OF PLATE 28

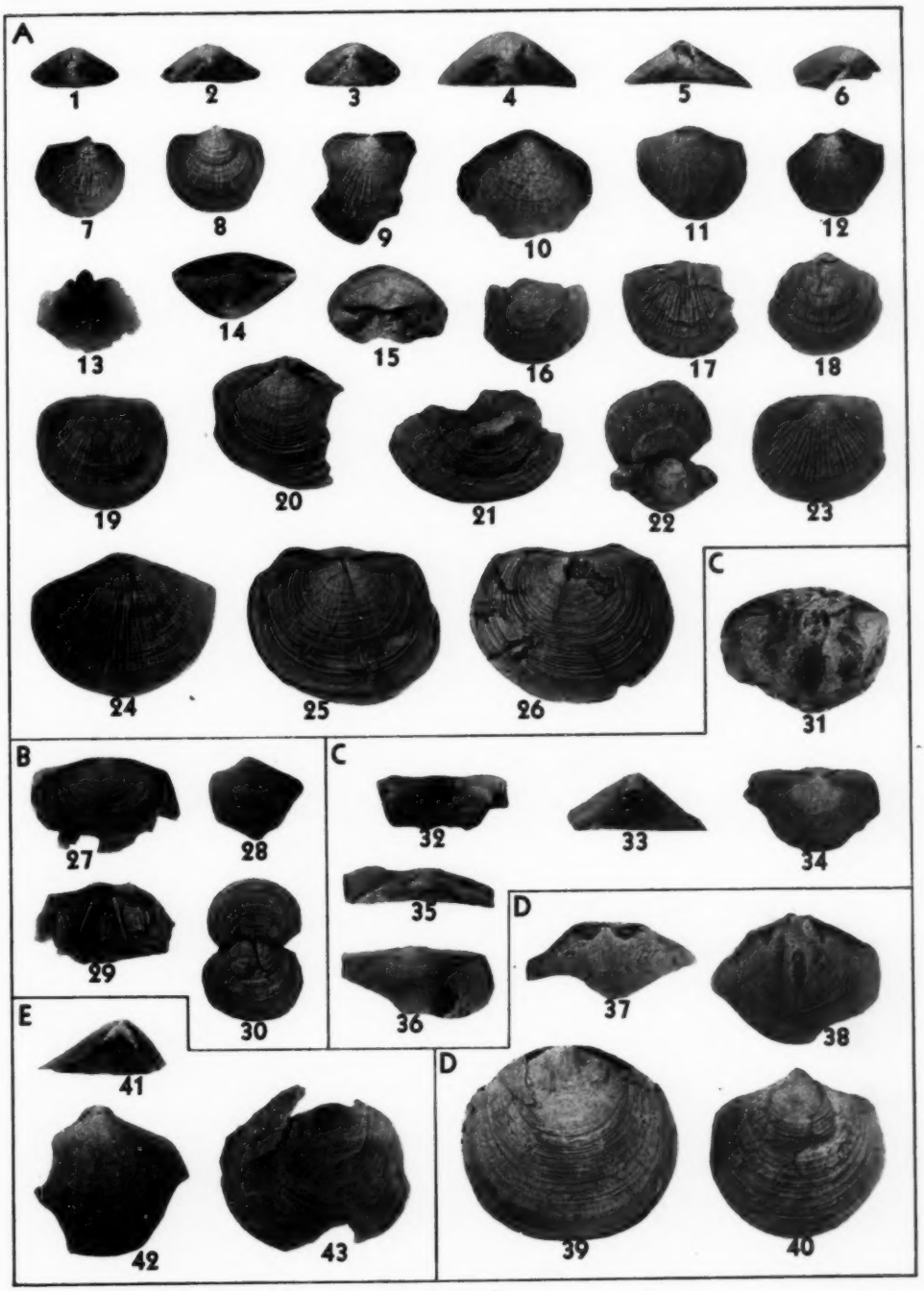
FIGS. *1–26—Micromitra sculptilis* (Meek) *1, 7*, Hypotype; posterior and apical views of ventral valve, Mich. 20814a, ×6, loc. M4-3. *2, 8*, Hypotype; posterior and apical views of ventral valve, Mont. T1205a, ×4, loc. 47-2T. *3, 9*, Hypotype; posterior and apical views of ventral valve, showing structure of apex and distinct propareas, U.S.N.M. 3467a, ×4, loc. 302. *4, 10*, Hypotype (Mon. 51, pl. 3, figs. 3, 3a–b, as holotype of *M. pealei*); posterior and apical views of ventral valve, showing propareas and homoeodeltidium, U.S.N.M. 26430a, ×4, loc. 155a. *5, 11*, Holotype (Mon. 51, pl. 3, fig. 5); posterior and apical views of incomplete ventral valve, U.S.N.M. 7864a, ×6, loc. 302. *6, 12*, Hypotype; posterior and apical views of ventral valve, showing a proparea and part of homoeodeltidium, Mont. T1205b, ×4, loc. 47-2T. *13*, Hypotype; interior of incomplete ventral valve, showing convex homoeodeltidium and projecting knob on each side of apex of delthyrium, Mont. T1204a, ×6, loc. 34-5U. *14*, Hypotype; posterior view of nearly complete specimen, the surface of which is similar to that of valve in fig. *12*, Mich. 20818a, ×4, loc. M3-1. *15, 20*, Hypotype; posterior and apical views of ventral valve, showing large homoeodeltidium, distinct propareas, and rectangular surface ornamentation, Mont. T1203a, ×4, loc. 26-3. *16*, Hypotype; apical view of incomplete dorsal valve, showing petaloid apex, Mont. T1203d, ×4, loc. 26-3. *17*, Hypotype; apical view of dorsal valve, showing a variation in surface ornamentation, Mont. T1207a, ×4, loc. 45-3. *18*, Hypotype; apical view of dorsal valve, showing a variation in surface ornamentation, Mont. T1206d, ×4, loc. 6-2. *19*, Hypotype; apical view of dorsal valve, Mont. T1206b, ×4, loc. 6-2. *21*, Hypotype; apical view of incomplete dorsal valve, showing petaloid apex, Mont. T1208a, ×6, loc. 45-2. *22*, Hypotype; apical view of associated incomplete dorsal and ventral valves, Mich. 20813a, ×6, loc. M4-4. *23*, Hypotype; apical view of dorsal valve, showing a variation in surface ornamentation, Mont. T1206c, ×4, loc. 6-2. *24*, Hypotype; apical view of crushed ventral valve, showing an extreme variation in surface ornamentation, Mont. T1206a, ×4, loc. 6-2. *25*, Hypotype; apical view of dorsal valve, showing propareas and homoeochilidium, Mont. T1203b, ×4, loc. 26-3. *26*, Hypotype; apical view of incomplete dorsal valve, showing propareas and healed injury, Mont. T1203c, ×4, loc. 26-3. Middle Cambrian: Meagher limestone (*Ehmania* and *Bathyuriscus* zones), "Pagoda" limestone, and Pentagon shale. (p. 205)

27–30—Micromitra? subdita Bell, n. sp. *27, 29*, Holotype; exterior and interior views of incomplete dorsal valve, Mont. T1211a, ×4, loc. 26-4. *28*, Paratype; apical view of crushed ventral valve, Mont. T1211b, ×4, loc. 26-4. *30*, Figured specimen; apical view of associated dorsal and ventral valves, Mich. 20815a, ×4, loc. M4-4. Middle Cambrian: Pentagon shale and Meagher limestone (*Bathyuriscus* zone). (p. 207)

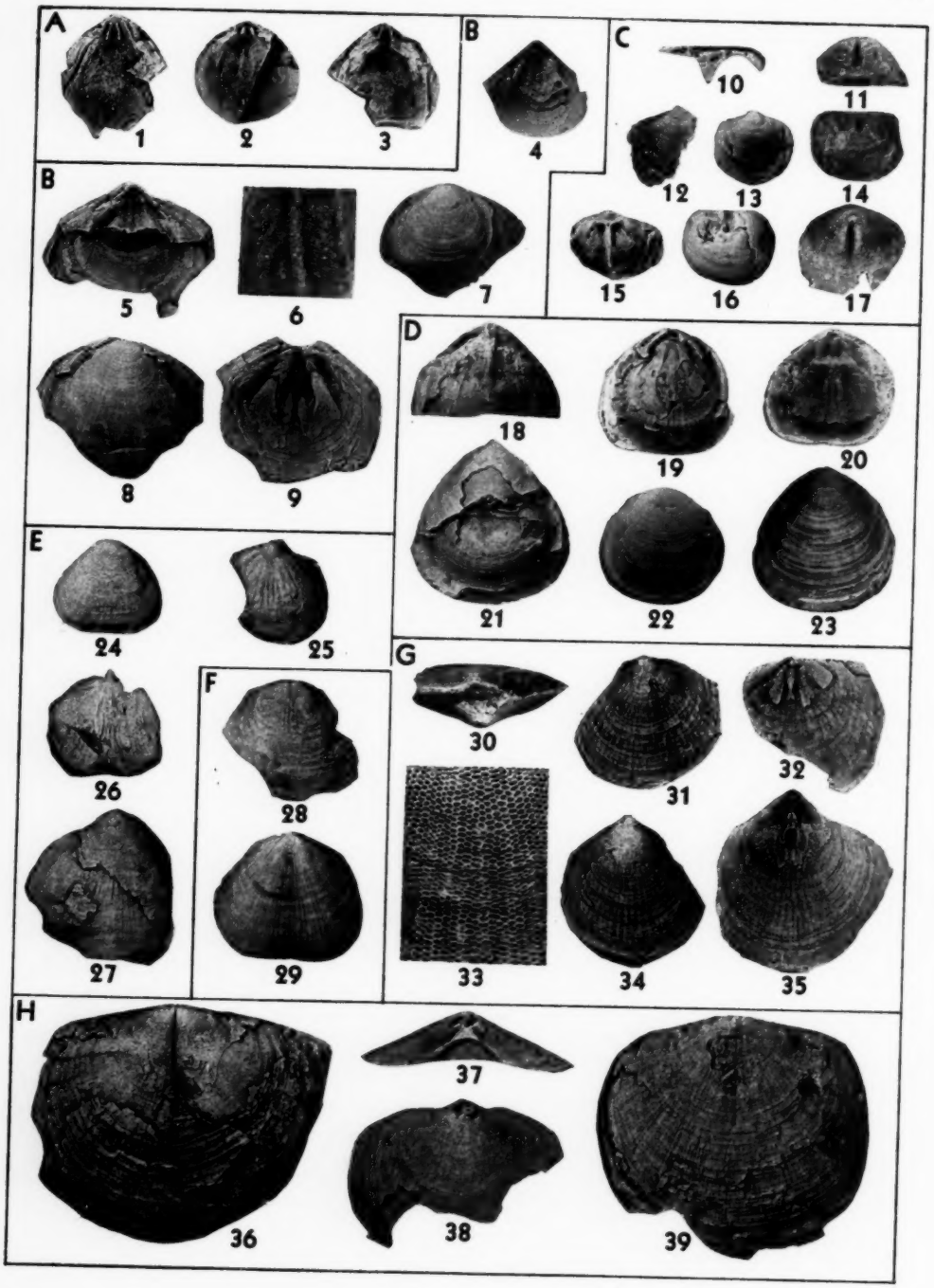
31–36—Icodonta typica Bell, n. gen., n. sp. *31*, Syntype; apical view of ventral internal mold, showing impressions of internal callosities and linear ridges bordering apex of delthyrium, Mont. T1210c, ×4, loc. 33-3L. *32*, Syntype; interior view of incomplete dorsal valve, showing subconical projection adjoining each posterolateral margin, Mont. T1210d, ×6, loc. 33-3L. *33, 34*, Syntype; posterior and apical views of incomplete ventral valve, showing propareas and short homoeodeltidium, Mont. T1210a, ×4, loc. 33-3L. *35, 36*, Syntype; posterior and apical views of incomplete dorsal valve, showing propareas and homoeochilidium with flattened crest, Mont. T1210b, ×4, loc. 33-3L. Middle Cambrian: Upper Wolsey shale. (p. 213)

37–40—Icodonta nixonensis Bell, n. gen., n. sp. *37*, Syntype; incomplete dorsal semi-internal mold, Mich. 20817b, ×4, loc. M4-1. *38*, Syntype; incomplete ventral semi-internal mold, Mich. 20817a, ×4, loc. M4-1. *39*, Syntype; exterior of partly exfoliated dorsal valve, Mich. 20817d, ×3, loc. M4-1. *40*, Syntype; exterior of nearly complete but somewhat crushed ventral valve, Mich. 20817c, ×3, loc. M4-1. Middle Cambrian: Wolsey shale. (p. 214)

41–43—Icodonta? cf. *I. nixonensis* Bell, n. gen., n. sp. *41, 42*, Figured specimen; posterior and apical views of incomplete ventral valve, Mont. T1212a, ×4, loc. 11-2. *43*, Figured specimen; external impression of incomplete and crushed valve, showing surface ornamentation like that in fig. *42*, Mont. T1213a, ×3, loc. 40-2. Middle Cambrian: Pagoda limestone and Wolsey shale. (p. 214)



Bell, Cambrian Brachiopoda



Bell, Cambrian Brachiopoda

terina solely because its

surface is formed by the union of the crenulated striae so as to form a fine network of raised obliquely arranged lines that divide the surface into minute pits that give the impression of finely woven cloth.

The type locality of the genotype, *Iphidella pannula* (White) is given (Walcott, 1912, p. 364) as "limestone interbedded in the Pioche shale, just above the quartzite on the east side of the anticline, near Pioche, Lincoln County, Nevada." Deiss (1938, p. 1156, loc. 56–1) collected specimens conspecific with the holotype, so far as can be determined, from 260 feet above the base of the Pioche shale on the west side of the Highland Range Nevada, thus substantiating the Lower Cambrian age of *I. pannula* in its type area.

EXPLANATION OF PLATE 29

FIGS. *1–3—Dicellomus politus* (Hall). *1, 2*, Hypotypes (Mon. 51, p. 576, t. figs. 49 A–B); interiors of ventral valves in which the surfaces of the propareas have been weathered away, U.S.N.M. 51917a–b, ×6, loc. 79s. *3*, Hypotype; interior of ventral valve in which the surfaces of the propareas have been only partly weathered away, U.S.N.M. 51917, ×6, loc. 79s. Upper Cambrian: Eau Claire member of Dresbach formation, Hudson, Wis. (p. 215)

4–9—Dicellomus mosaica Bell, n. sp. *4*, Paratype; interior of incomplete ventral valve, Mont. T1202d, ×4, loc. 44-2. *5*, Paratype; interior of incomplete ventral valve, Mont. T1202b, ×4, loc. 44-2. *6*, Figured specimen; magnified view of pitted surface pattern, Mich. 20812b, ca. ×30, loc. M1-4. *7*, Paratype: exterior of partly exfoliated dorsal valve, Mont. T1202c, ×4, loc. 44-2. *8*, Figured specimen; exterior of partly exfoliated dorsal valve, Mich. 20812a, ×4, loc. M1-4. *9*, Holotype; interior of dorsal valve, showing muscular scars, Mont. T1202a, ×4, loc. 44-2. Upper Cambrian: Dry Creek shale and Snowy Range formation. (p. 216)

10–17—Ceratreta hebes Bell, n. gen., n. sp. *10, 12*, Syntype; lateral and exterior views of an incomplete dorsal valve, showing hornlike projection of septum, Mont. T1197a, ×8, loc. 46-3. *11, 14*, Syntype; posterior and apical views of partly exfoliated ventral valve, Mont. T1197b, ×8, loc. 46-3. *13*, Syntype; exterior of nearly complete dorsal valve, Mont. T1197e, ×8, loc. 46-3. *15*, Syntype; interior of an incomplete dorsal valve, showing apical shelf and narrow septum from which the hornlike projection has been broken, Mont. T1197d, ×10, loc. 46-3. *16*, Syntype; apical view of partly exfoliated ventral valve, showing cross section of internal pedicle tube near posterior margin, Mont. T1197f, ×8, loc. 46-3. *17*, Syntype; posterior view of nearly perfect ventral valve, showing blunt apex and deep intertrough incised in apical half of pseudointerarea, Mont. T1197c, ×8, loc. 46-3. Upper Cambrian: Dry Creek shale. (p. 233)

18–23—Dicellomus occidentalis Bell, n. sp. *18*, Syntype; internal mold of incomplete ventral valve, showing propareas and long pedicle furrow merging into spatulate visceral area, Mont. T1200f, ×4, loc. 32-3. *19*, Syntype; surface of partly exfoliated dorsal valve, showing large central muscular scars, Mont. T1200d, ×4, loc. 32-3. *20*, Syntype; interior of nearly complete dorsal valve, showing small anterior lateral muscular scars in contact with anterior ends of the large elongate central scars, Mont. T1200c, ×4, loc. 32-3. *21*, Syntype; exterior of partly exfoliated ventral valve, showing thick laminated shell and radiating bands on inner layers, Mont. T1200e, ×4, loc. 32-3. *22, 23*, Syntypes; exteriors of dorsal and ventral valves, Mont. T1200a–b, ×4, loc. 32-3. Upper Cambrian: Pilgrim limestone. (p. 218)

24–27—Schuchertina cambria Walcott. *24, 27*, Paratypes (Mon. 51, pl. 51, figs. 6g, 6a); exteriors of two ventral valves, U.S.N.M. 51411f, 51411b, ×1, loc. 5k. *25*, Holotype (Mon. 51, pl. 51, figs. 6b–c, as ventral valve); internal mold of a dorsal valve, U.S.N.M. 51411c, ×1, loc. 5k. *26*, Paratype (Mon. 51, pl. 51, fig. 6j, as a dorsal valve); internal mold of ventral valve, U.S.N.M. 51411h, ×1, loc. 5k. Middle Cambrian: Meagher limestone. (p. 215)

28, 29—Schuchertina cf. *S. cambria* Walcott. *28*, Figured specimen; internal mold of incomplete dorsal valve, Mont. T1193b, ×1, loc. 42-2. *29*, Figured specimen; internal mold of incomplete dorsal valve, Mont. T1193a, ×2, loc. 42-2. Middle Cambrian: Meagher limestone. (p. 215)

30–35—Iphidella hexagona Bell, n. sp. *30, 31, 34*, Syntype; posterior, dorsal, and ventral views of a nearly complete specimen, Mich. 20816a, ×4, loc. M3-1. *33*, Syntype; enlarged view of surface ornamentation of same specimen, Mich. 20816a, ×15, loc. M3-1. *32*, Syntype; interior of incomplete dorsal valve, U.S.N.M. 97078a, ×4, loc. 20k. *35*, Syntype; interior of incomplete ventral valve, Mich. 20816b, ×4, loc. M3-1. Middle Cambrian: lower Meagher limestone. (p. 210)

36–39—Iphidella nyssa Walcott. *36*, Paratype (Mon. 51, pl. 3, fig. 9a); exterior of crushed and partly exfoliated dorsal valve, U.S.N.M. 51441b, ×3, loc. 4q. *37, 38*, Hypotype; posterior and apical views of incomplete ventral valve, Mont. T1209a, ×3, loc. 23-1. *39*, Holotype (Mon. 51, pl. 3, fig. 9, as a ventral valve); exterior of crushed and partly exfoliated dorsal valve, U.S.N.M. 51441a, ×3, loc. 4q. Middle Cambrian: Gordon shale. (p. 212)

The species has been reported from British Columbia, Alberta, Montana, Idaho, Utah, Nevada, Arizona, New York, Tennessee, and Georgia; and from rocks ranging in age from Lower to Upper Cambrian. Obviously, as now conceived, *I. pannula* possesses neither stratigraphic nor geographic significance, and must be restudied. This problem cannot be undertaken in the present study, but it is thought that certain observations on the genotype can with profit be included here.

The holotype of *Iphidella pannula* (White) is a badly weathered shell fragment, which has a faint surface pattern composed of imperfect diamond-shaped pits formed by the oblique intersection of narrow ribs. The only topotype in the United States National Museum which is not defaced to some extent shows a distinct quincunxial pattern in which the diamond-shaped spaces between the ridges are somewhat filled and rounded. This pattern is diagrammatically shown by Walcott (1912, pl. 4, fig. 1o). None of the specimens from the type locality shows any details of the interarea, but a ventral valve from U.S.N.M. loc. 30 (Walcott, 1912, pl. 4, figs. 1d, 1e), also in Lincoln County, has a short homoeodeltidium and ill-defined propareas. The ornamentation of this shell apparently consists of imperfect hexagonal pitting, with a trace of quincunxial ridging near the margin. A single nearly complete ventral valve from loc. 56-1 (Deiss, 1938, p. 1156) shows a pattern identical with that on the topotypes, but no evidence of propareas or a homoeodeltidium. The topotypes and specimens apparently conspecific with them range in width from 2–3 mm.

It appears from this brief survey of specimens from the type and nearby localities in the Pioche shale, that *Iphidella pannula* is characterized by a calcaroecorneous shell composed of a single layer, transversely subelliptical outline, obliquely subconical ventral valve with obtusely pointed overhanging apex, nearly flat dorsal valve, surface pattern of diamond-shaped pits produced by the oblique intersection of narrow ridges, and perhaps distinct propareas and a short homoeodeltidium.

Until the species at present assigned to *Iphidella* can be restudied, the genus may be tentatively considered as having a *Micromitra*-like form, with a pitted surface ornamentation.

IPHIDELLA HEXAGONA Bell, n. sp.
Plate 29, figures 30–35

Iphidella pannula (White). WALCOTT (part), *1912*, U. S. Geol. Survey, Mon. 51, pl. 4, figs. 1b, 1f, 1t (not figs. 1, 1a, 1c–e, 1g–s).

Outline subsemicircular except for pointed ventral beak (apical angle 110°–120°) projecting well posterior to line of valve junction, which is slightly less than greatest width of shell; surface covered by radiating rows of adjacent hexagonal pits, the hexagons of each row interlocking alternately with hexagons of bordering rows; each row retains its identity from apex nearly to margin, with rare intercalation of new rows; pits minute and indistinct near apex becoming progressively larger and more transverse toward margin, and finally replaced by irregular concentric ridges in some gerontic shells; shell thick, calcareocorneous, composed of a single layer.

Ventral valve: Convexity slight near anterior margin, increasing strongly along median axis to highest point slightly posterior to line of valve junction; apex slightly incurved over delthyrium, smooth, pointed, with pair of low callosities anterolateral to it, as is *Micromitra sculptilis* (Meek); propareas narrow, smooth or granular, unstriated; delthyrium high, triangular; delthyrial angle about 135°; homoeodeltidium probably minute, if present, but not observed. Delthyrial cavity with a pair of narrow subparallel furrows, which diverge anteriorly around a high elongate callosity situated about at the line of valve junction; callosity splits anteriorly into a pair of low, broad elevations which curve around an elongate elliptical depression and approach each other again toward middle of valve (pl. 29, fig. 35).

Dorsal valve: Profile moderately convex, highest point being at umbo vertically above line of valve junction; apex slightly incurved over notothyrium, rounded, bearing a smooth petaloid callosity, as in *Micromitra sculptilis;* propareas narrow, smooth or granular, unstriated; notothyrium low, widely triangular; notothyrial angle about 135°; homoeochildium not observed in the types. Notothyrial cavity with short median cal-

losity, from posterior end of which a pair of broad flabellate elevations diverge anteriorly (pl. 29, fig. 32).

Syntypes, Mich. 20816a-b, U.S.N.M. 97078a.

Horizon and locality.—Middle Cambrian. Meagher limestone (*Ehmania* zone): *M3-1* U.S.N.M. localities *20k* and 149a (?), *Pole Creek*. Pagoda limestone: 11-2, Dearborn Canyon; 30-2, Cliff Mt.; 51-1, Prairie Reef Mt.

Distinguishing characters.—*Iphidella hexagona* is characterized by its ventral valve being extended posteriorly into an obtusely acuminate beak, the apex of which lies well beyond the line of valve junction; a widely triangular delthyrium, oriented in a plane 35°–40° apsacline, with perhaps a minute homoeodeltidium at its apex; a surface ornamentation composed of radiating rows of interlocking hexagonal pits; and internal structures so far unknown in any other brachiopod.

Discussion.—This species is assigned at present to *Iphidella*, but with the expressed belief that when the internal characters of *I. pannula* are made known the two species will be found to differ generically. The writer hesitates to establish a monotypic genus upon a species whose morphology is so incompletely understood, and which belongs to such a poorly known group of species as those now assigned to *Micromitra*, *Paterina*, and *Iphidella*.

The pattern of internal callosities in *Iphidella hexagona*, which presumably represent points of muscular attachment, remotely resembles that in the most primitive calcareous "articulates." This is particularly true in the ventral valve, where the median callosity may have borne the "adductors" and the pair of callosities anterior to it, the "diductors." Numerous specimens of *I. hexagona* in which the two valves are still "articulated" are known from the Pagoda formation of northwestern Montana, suggesting that perhaps some form of articulation had been developed in this species, but no structures have been observed that might have functioned in such a manner.

Walcott (1912, pp. 335, 362, pl. 4, figs. 1b, 1f) illustrated and discussed a dorsal valve from U.S.N.M. loc. 149a, Pole Creek, several miles east of the type locality of *I. hexagona*. He described a "narrow median groove extending from the apex to the posterior margin of the pseudodeltidium" (homoeochilidium). This groove is unquestionably the result of crushing. An associated undeformed dorsal valve has a large homoeochilidium with a low median callosity at its margin (compare pl. 28, fig. 35). Walcott also stated that "striae of growth extend across the false areas and pseudodeltidia in both valves." On the contrary, the propareas in *I. hexagona* are smooth or granular, unstriated, and sharply separated from the ornamented portion of the valve. They are, in fact, identical with the propareas in *Micromitra sculptilis*.

The shells from U.S.N.M. loc. 149a are somewhat doubtfully referred to *Iphidella hexagona*. Their large size and the presence of a large homoeochilidium in the dorsal valve suggest *I. nyssa* Walcott. However, the internal radial banding present in the types of *I. nyssa* is not present in the specimens from loc. 149a, and the surface pits on the latter species are distinctly hexagonal, whereas the pits on *I. nyssa* are quadrangular or subcircular.

Iphidella hexagona closely resembles *Iphidella pannula maladensis* (Walcott), from which it differs in the outline of the ventral valve, and in surface ornamentation. From *Iphidella eguchii* Resser and Endo (1937, p. 109, pl. 21, figs. 14, 15), which apparently has an identical surface pattern, it seems to differ in the form of the ventral valve.

	Dimensions (mm.)				
	Length	Width	Height	L/W	H/W
Ventral valves:					
Mich. 20816a	5.3?	5.5?	1.0?	0.96	0.18
Mich. 20816b	6.5?	7.5?		0.87	
Dorsal valves:					
Mich. 20816a	4.6?	5.5?		0.84	
U.S.N.M. 97078a	5.0?	6.5?		0.77	

IPHIDELLA NYSSA Walcott
Plate 29, figures 36–39

Micromitra (*Iphidella*) *nyssa* WALCOTT, *1908*, Smithsonian Misc. Coll., vol. 53, no. 3, p. 57, pl. 7, fig. 5; WALCOTT, *1912*, U. S. Geol. Survey, Mon. 51, p. 360, pl. 3, figs. 9, 9a.

Shell large for the genus; outline somewhat transversely subelliptical except for slight truncation of posterior margin; line of valve junction considerably shorter than greatest width of shell; surface covered by adjacent subquadrangular pits, roughly arranged in radiating rows, and apparently produced by oblique intersection of raised ridges; shell calcareocorneous, composed of a single layer.

Ventral valve: Profile subtrigonal, with highest point above line of valve junction; apex broken on hypotype, but probably slightly incurved; delthyrium moderately high, widely triangular; delthyrial angle about 100°; apical third of delthyrium closed by homoeodeltidium; propareas wide, smooth, continuous with homoeodeltidium; homoeodeltidium thick, strongly convex, with lower margin arched and continuous with sides of delthyrium. Interior unknown.

Dorsal valve: Profile probably slightly convex, with highest point above line of valve junction; character of apex unknown; propareas smooth and unstriated; homoeochilidium present in holotype, short, thick, nearly flush with propareas. Interior unknown except for adjacent narrow radiating bands visible on internal mold of holotype.

Discussion.—The type lot of *I. nyssa* in the U. S. National Museum comprises only dorsal valves, the holotype being a dorsal instead of a ventral valve as described by Walcott (1912, pl. 3, fig. 9). It possesses a broad short homoeochilidium, crushed inward and broken. The ventral valve from loc. 23-1 (pl. 29, figs. 37–38) is designated a hypotype of this species because of its large size, transversely subelliptical outline, similar surface pattern, and occurrence near the type locality. Quite probably when the internal characters of *I. pannula* and *I. nyssa* are made known, the two species will be found to differ generically.

Genus ICODONTA Bell, n. gen.
(Gr. εἰκός, perhaps; ὀδόγτος, teeth)

Outline subcircular to somewhat transversely subelliptical, posterior margin slightly truncated; line of valve junction less than greatest width of shell; surface coarsely and evenly filate, with irregular and discontinuous radiating crenulations in apical portion of the genotype; shell substance calcareocorneous, homogeneous, thick.

Ventral valve: Profile triangular, greatest height at pointed apex, which is at or slightly anterior to line of valve junction; propareas distinct, smooth, sometimes with a few ridges or grooves which are not continuous with fila; delthyrium high, widely triangular; delthyrial angle about 80°; homoeodeltidium thick, sharply separated from propareas, ridged or striated parallel to arched lower margin, and covering less than a third of delthyrium. Interior with broad, elongate median callosity near middle of anterior slope, bordered by pair of broad, slightly elongate, but less high callosities; pair of narrow elongate ridges border apex of delthyrium (pl. 28, fig. 31).

Dorsal valve: Profile slightly convex, with highest point at broadly rounded apex above line of valve junction; propareas distinct, smooth; notothyrium low, widely triangular, notothyrial angle about 110° in genotype;

Dimensions (mm.)

	Length	Width	Height	L/W	H/W
Ventral valve:					
Mont. T1209a	8.0?	10.3?	2.3?	0.78	0.21
Dorsal valves:					
U.S.N.M. 51441a	11.5?	12.8?		0.90	
U.S.N.M. 51441b	11.7?	15.0?		0.78	

Holotype, U.S.N.M. 51441a; paratype, U.S.N.M. 51441b; hypotype, Mont. T1209a.

Horizon and locality.—Middle Cambrian. Upper Gordon shale: 9-2 (?), Pagoda Mt.; 23-1, head of Ahorn Creek; 53-1, Kid Mt.; U.S.N.M. localities *4q, ridge between Gordon and Youngs Creeks;* 4v, Gordon Creek.

Distinguishing characters.—*Iphidella nyssa* is distinguished from all species at present assigned to the genus by its large size, form of the ventral valve, excessively wide delthyrium, and subrectangular surface pits.

homoeochilidium present in genotype, thick, distinctly separated from propareas, gently arched at lower margin, bearing median flattening or ridge, and covering about a third of notothyrium. Interior with a large callosity (subconical in genotype, with cuplike depression lateral to it) on each side of notothyrium near posterior margin (pl. 28, fig. 32).

Genotype, *Icodonta typica* Bell, n. sp.

Discussion.—The species referred to *Icodonta* in this paper would normally be assigned to *Paterina* upon the basis of their *Micromitra*-like form and their strong and regular fila. A mention of the present uncertainty regarding the morphology and relationships of *Paterina* has been made under the discussion of *Micromitra*. In light of that uncertainty, and because the species here assigned to *Icodonta* appear to differ from the genotype of *Micromitra* in several fundamental respects, the genus *Icodonta* is proposed.

Icodonta is distinguished from *Micromitra* by its much thicker shell, particularly in the genotype, its short and thick homoeodeltidium and homoeochilidium, which appear to be individually secreted plates rather than convex continuations of the propareas as in *Micromitra sculptilis*, and by internal structures, which have not been observed in the genotype of *Micromitra*.

The internal morphology of *Icodonta*, best known in *I. typica*, is of particular interest. The strong median and bounding callosities in the ventral valve (pl. 28, figs. 31, 38) presumably are for muscular implantation and remotely resemble, as in the case of *Iphidella hexagona* (pl. 29, fig. 35) described in this paper, the primitive orthid muscular pattern. A similarity between *Icodonta typica* and *Micromitra sculptilis* is seen in the pair of linear ridges bordering the apex of the delthyrium (pl. 28, figs. 13, 31). No function has been postulated for these projections.

The most interesting internal structures observed in *Icodonta* appear in the dorsal valve. A prepared fragment of a dorsal valve of *I. typica* (pl. 28, fig. 32) and a compressed valve of *I. nixonensis* (pl. 28, fig. 37) reveal strong thickenings of the shell on both sides of the notothyrium near the posterior margin of the valve. In *I. typica*, where they can best be observed, the thickenings are in the form of a pair of subconical projections, with a cuplike depression adjacent and lateral to each. These projections appear to be analogous to the brachiophores of the primitive orthids, and the cuplike depressions are tentatively construed to be sockets for the reception of teeth in the ventral valve. Unfortunately, the presence or absence of teeth could not be positively ascertained with the specimens available.

The present study of *Icodonta* and *Iphidella hexagona* has revealed types of internal morphology that suggest closer affinities between the so-called articulates and inarticulates than has heretofore been suspected. However, until the internal morphology of other species in the *Micromitra-Paterina-Iphidella* group is made known, little can be gained by speculation regarding the apparent affinities.

ICODONTA TYPICA Bell, n. sp.
Plate 28, figures 31–36

Outline subsemicircular; line of valve junction slightly less than greatest width of shell; surface fila distinct, rounded, smoothly concentric, gradually increasing in size from apex to margin, rarely bifurcating and coalescing, and regularly spaced at intervals equal to width of each filum; several low, narrow, irregular, discontinuous crenulations or ridges, on which fila may or may not be obliterated, radiate from apex of each valve and extend toward middle of anterior slope; shell calcareocorneous, homogeneous, thick.

Ventral valve: Profile trigonal, highest point at erect, obtusely pointed apex, which is vertically above or slightly anterior to line of valve junction; propareas flat, smooth except for irregularly spaced vertical grooves, which are separated from filate portion of valve by sharp ridges; delthyrium high, triangular; delthyrial angle about 80°; homoeodeltidium convex, short, thick, sharply separated from propareas, ridged parallel to lower arched margin, and occupying nearly a third of the delthyrium. Interior with high, longitudinally elliptical callosity situated about halfway from apex to anterior margin; low subcircular callosity about halfway from apex to margin on each anterolateral slope; pair of short, narrow ridges border apex of delthyrium.

Dorsal valve: Profile slightly convex, highest point at rounded apex vertically above line of valve junction; propareas flat, smooth; notothyrium low, widely triangular; notothyrial angle about 110°; homoeochilidium convex, thick, ridged parallel to gently arched margin, covering about a third of notothyrium, sharply separated from propareas, flattened on top to form triangular surface, whose sides diverge from apex. Interior with a subconical projection on each side of notothyrium near posterior margin of valve, each projection having a cuplike depression adjacent and lateral to it.

Dimensions (mm.)

	Width	Height	H/W
Ventral valves:			
Mont. T1210a....	5.0?	2.1	0.42
Mont. T1210c....	6.0?		
Dorsal valve:			
Mont. T1210b....	5.5?	1.2	0.22

Syntypes, Mont. T1210a–d.

Horizon and locality.—Middle Cambrian. Limestone lenses in upper part of Wolsey shale: *33-3L*, 33-3U, *Keegan Butte.*

Distinguishing characters.—This species is characterized by shell outline and profile, radiating crenulations on umbo, flattened surface on homoeochilidium, and internally by a pair of subconical projections on the posterolateral margins of the dorsal valve.

Discussion.—The internal characters of *I. typica* have been discussed in connection with the genus.

The ventral valve of *Paterina stuarti* Walcott resembles that of *I. typica* internally but differs distinctly from it in profile and surface characters.

Icodonta nixonensis Bell, n. sp.
Plate 28, figures 37–40

All specimens from the type locality have been obtained from a soft shale and occur in a flattened condition.

Outline subcircular except for obtusely acuminate ventral beak; line of valve junction less than greatest width of shell; surface very evenly and coarsely filate; shell calcareocorneous, probably quite thick in original state.

Ventral valve: Propareas apparently present, smooth; character of delthyrium and homoeodeltidium, if present, unknown on specimens from type locality. Interior with an elongate callosity near middle of anterior slope, bordered by a pair of less distinct, elongate callosities; apparently a pair of narrow, high ridges border apex of delthyrium (compare with *I. typica*).

Dorsal valve: Interior with posterolateral margins strongly thickened.

Dimensions (mm.)

	Length	Width	L/W
Ventral valve:			
Mich. 20817c.....	7.8	8.2	0.95
Dorsal valve:			
Mich. 20817d.....	9.2	10.0	0.92

Syntypes, Mich. 20817a–d.

Horizon and locality.—Middle Cambrian. Upper Wolsey shale: *M4-1*, 45-1, *Nixon Gulch;* 40-2, Big Snowy Mts. Pagoda limestone: 11-2 (?), Dearborn Canyon.

Distinguishing characters.—This species is distinguished from *I. typica* by its somewhat more regular and coarse fila and its lack of radial crenulations near the apex.

Discussion.—Two semi-internal molds (pl. 28, figs. 37–38) from the type locality show an internal morphology which approximates that in *I. typica*. The exact bilateral arrangement of both the dorsal and ventral structures seems to rule out any possibility of their being accidental, but their manner of occurrence is inexplicable. The specimens have every appearance of being internal impressions of valves that had strong internal thickenings, but, strangely enough, a thin layer of shell substance, carrying the surface fila, covers much of each "internal mold." Possibly solution has removed all but a thin surface layer of the shell, which has been pressed down upon the internal mold.

A single ventral valve (pl. 28, figs. 41–42) from the Pagoda limestone in Dearborn Canyon is assigned tentatively to this species because it has regular and coarse fila and lacks radial crenulations near the apex. Except for these surface characters, the valve is essentially identical in form with the ventral valve of *Icodonta typica*. Its ornamentation differs slightly from that of *I. nixonensis* in that the fila are broken or subdued in such a manner that numerous narrow bands, uncrossed by fila, radiate toward the shell margin. An external impression (pl. 28, fig. 43) of a valve from the Wolsey shale in the Big Snowy Mountains has the same ornamentation as the ventral valve

from the Pagoda limestone. These two specimens may belong to a new species of *Icodonta* or to some other genus, but because they are the only specimens from their respective localities, they are assigned for the present to *I. nixonensis*, with which they appear to have the closest affinities.

Genus SCHUCHERTINA Walcott, 1905
SCHUCHERTINA CAMBRIA Walcott
Plate 29, figures 24–27

Schuchertina cambria WALCOTT, *1905*, U. S. Nat. Mus., Proc., vol. 28, p. 323;——*1912*, U. S. Geol. Survey, Mon. 51, p. 585, pl. 51, figs. 6, 6a–m.

Four very poorly preserved specimens (pl. 29, figs. 28–29) from Checkerboard Creek are tentatively assigned to this species. They add no information regarding the unique internal markings of *Schuchertina cambria*.

A study of the type specimens of *S. cambria* suggested to the writer that Walcott was in error in certain of his interpretations of the species. The shell material (?) is dark-grey structureless calcite, without either exo- or endo-punctae. It effervesces violently in acid and leaves no residue. The ventral valve is subtrigonal in outline and the dorsal valve somewhat transversely ovate. In the writer's opinion Walcott misinterpreted the dorsal and ventral interiors, his (1912, pl. 51) figures 6, 6a, 6g, 6j–k being ventral valves, and the figures 6b–c, 6d–e, 6h–i, 6l–m being dorsal valves. None of the internal markings appears to be a muscular scar, and Walcott's comparison of the musculature to that in the Billingsellidae seems to be without foundation. However, no alternative interpretation for the markings is proposed, except to suggest that they are entirely pallial in origin.

The original locality from which *Schuchertina cambria* was collected has never been rediscovered, and consequently its exact stratigraphic position is unknown. The specimens in the United States National Museum collection labeled loc. 5k occur in two kinds of matrix. One, a light-colored, coarsely crystalline limestone, carries specimens of *Dicellomus occidentalis* Bell, n. sp.; and the other, a dark-grey, finely crystalline limestone, contains *Micromitra sculptilis* (Meek) *Nisusia* cf. *N. deissi* Bell, n. sp., and *Schuchertina cambria*. Trilobites in the latter matrix belong to new genera according to Resser.[5] Apparently the collection from loc. 5k was made from both Middle and Upper Cambrian rocks. Because the brachiopods associated in the same matrix with *S. cambria* at loc. 5k are species known elsewhere from the Meagher limestone, and in light of the discovery of *S.* cf. *S. cambria* in the Meagher limestone on Checkerboard Creek, the horizon of *S. cambria* seems definitely assignable to the Meagher.

Dimensions (mm.)

	Length	Width	L/W
Ventral valves:			
U.S.N.M. 51411f..	13.2	16.0	0.83
U.S.N.M. 51411h.	15.0	16.0	0.94
Dorsal valve:			
U.S.N.M. 51411c..	14.0	17.0?	0.82

Holotype, U.S.N.M. 51411c; paratypes, U.S.N.M. 51411a–b, d–j; figured specimens, Mont. T1193a–b.

Horizon and locality.—Middle Cambrian. Meagher limestone: 42-2 (?), Checkerboard Creek; U.S.N.M. loc. *5k* (1), *head of Sawmill Creek*.

Genus DICELLOMUS Hall, 1873
Plate 29, figures 1–3

In his discussion of the genotype, *Dicellomus politus* (Hall), Walcott (1912, p. 576, text figs. 49A–B) illustrated a structure which he described as

> . . . a concave plate in the pedicle furrow, the edges of which rise above the plane of the cardinal area; this plate is evidently the beginning in *Dicellomus* of the pedicle tube. . . .

The specimens from which Walcott's drawings were made are illustrated on plate 29, figures 1, 2. These interiors are associated with many others like them on the surface of a fine-grained yellow sandstone, and have been exposed by weathering. The vascular nature of the "cardinal areas" bordering the so-called "pedicle tube" appeared to the writer to be abnormal, a belief that was substantiated when the specimen illustrated on plate 29, figure 3, was found, associated with the valves noted by Walcott. The "pedicle tube" is a structure produced by the weathering away of the surface layer of the propareas, leaving the margins of the pedicle furrow standing free. Thus, the ventral pseudointerarea is of normal atremate char-

[5] Personal communication.

acter, and except that the flat propareas are steeply inclined toward each other, the pseudointerarea of *Dicellomus politus* resembles closely that of species of "*Obolus*" and "*Lingulella*" associated with it.

Walcott (1912, p. 572, pl. 52, figs. 1i–j) illustrated two dorsal valves in which the posterolateral margins are

> hollowed out so as to form a shallow groove on each side, apparently for the reception of the short tooth of the ventral valve.

These two valves now have the posterior margin broken away. The writer has never seen a posterior margin such as that illustrated and described by Walcott in any other specimen of *Dicellomus*. Inasmuch as the structure designated a "tooth" by Walcott is in reality the projecting corner of the mistakenly identified "pedicle tube," the interpretation of *Dicellomus* as an "articulate" brachiopod should be regarded with suspicion until further substantiated.

DICELLOMUS MOSAICA Bell, n. sp.
Plate 29, figures 4–9

Dicellomus nanus (Meek and Hayden). WALCOTT (part), 1912, U. S. Geol. Survey, Mon. 51, pl. 53, figs. 3, 3c–d.

Outline transversely subelliptical except for obtusely acuminate ventral beak; apical angle about 125°; profile moderately and subequally biconvex, the greatest height near middle of shell; surface subdued and sparsely filate, closely and minutely pitted; shell calcareocorneous, composed of several

---

EXPLANATION OF PLATE 30

FIGS. *1–3—Acrothele colleni* Walcott. *1, 2*, Paratype (Mon. 51, pl. 63, fig. 6a); posterior and apical views of incomplete ventral valve, U.S.N.M. 51973b, ×4, loc. 4q. *3*, Hypotype; exterior of incomplete dorsal valve showing preumbonal depression and tubercles at apex, U.S.N.M. 51973d, ×4, loc. 4q. Middle Cambrian: Gordon shale. (p. 219)

4–7—Acrothele clarki (Walcott). *4, 7*, Paratypes (Mon. 51, pl. 82, figs. 7a–b); internal molds of ventral valves, U.S.N.M. 52214b–c, ×4, loc. 9k. *5*, Paratype (Mon. 51, pl. 82, fig. 7c); internal mold of incomplete dorsal valve, U.S.N.M. 52214d, ×4, loc. 9k. *6*, Holotype (Mon. 51, pl. 82, fig. 7, as holotype of *Dearbornia clarki*); internal mold of ventral valve, showing fragment of corneous shell substance enclosing cast of pedicle tube, U.S.N.M. 52214a, ×4, loc. 9k. Middle Cambrian: possibly Damnation limestone. (p. 219)

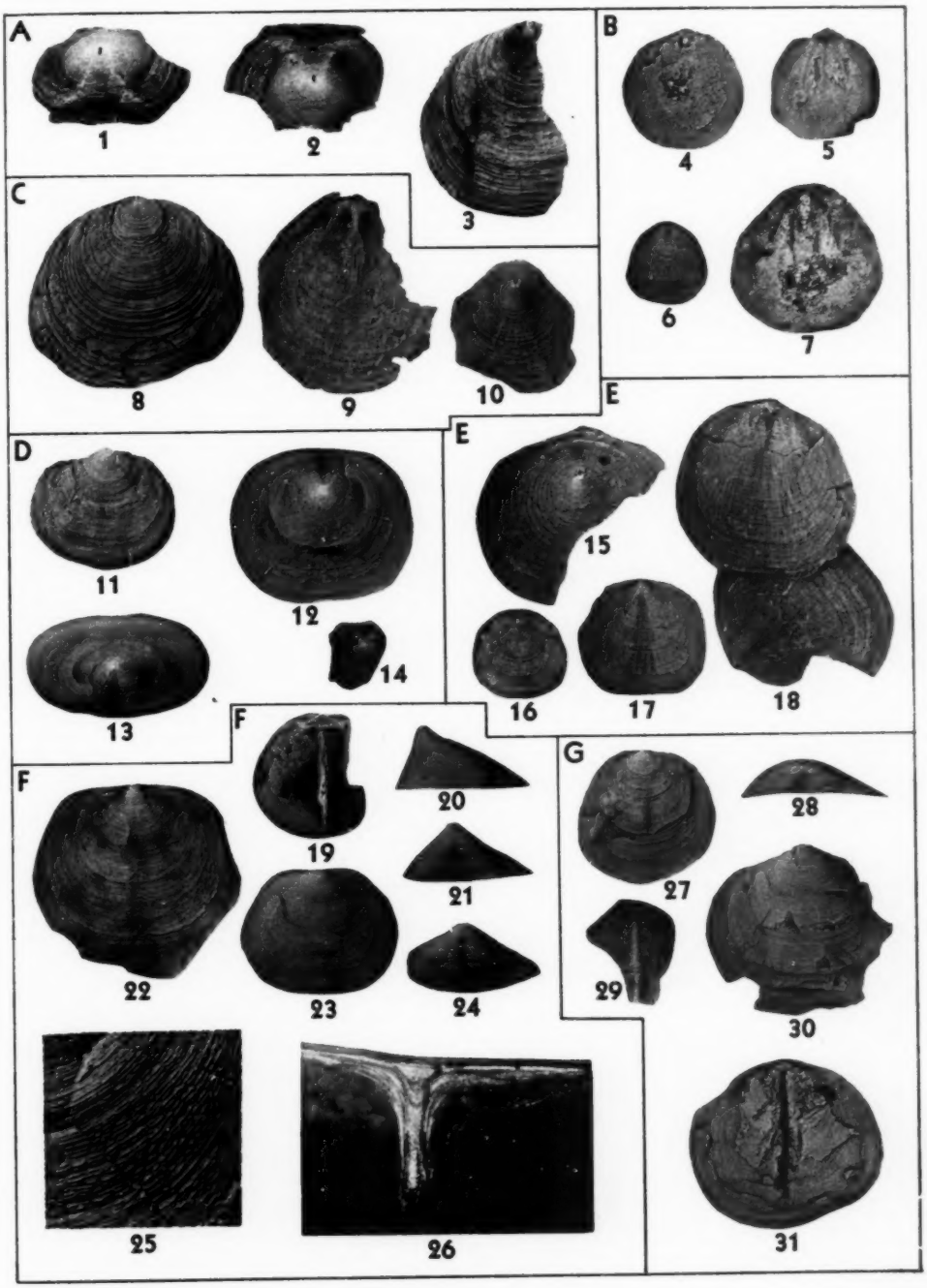
8–10—Acrothele pentagonensis Bell, n. sp. *8, 9*, Syntypes; exterior and interior of dorsal valves, Mont. T1196b–c, ×3, loc. 26-4. *10*, Syntype; apical view of incomplete ventral valve, Mont. T1196a, ×3, loc. 26-4. Middle Cambrian: Pentagon shale. (p. 221)

11–14—Pegmatreta perplexa Bell, n. gen., n. sp. *11*, Syntype; exterior of crushed dorsal valve, Mich. 20810b, ×10, loc. M4-4. *12, 13*, Syntype; apical and posterior views of ventral valve, Mich. 20810a, ×10, loc. M4-4. *14*, Syntype; interior of apex of ventral valve, showing subconical callosity with deep pit excavated into its posterior slope, Mich. 20810c, ×10, loc. M4-4. Middle Cambrian: Meagher limestone (*Bathyuriscus* zone). (p. 232)

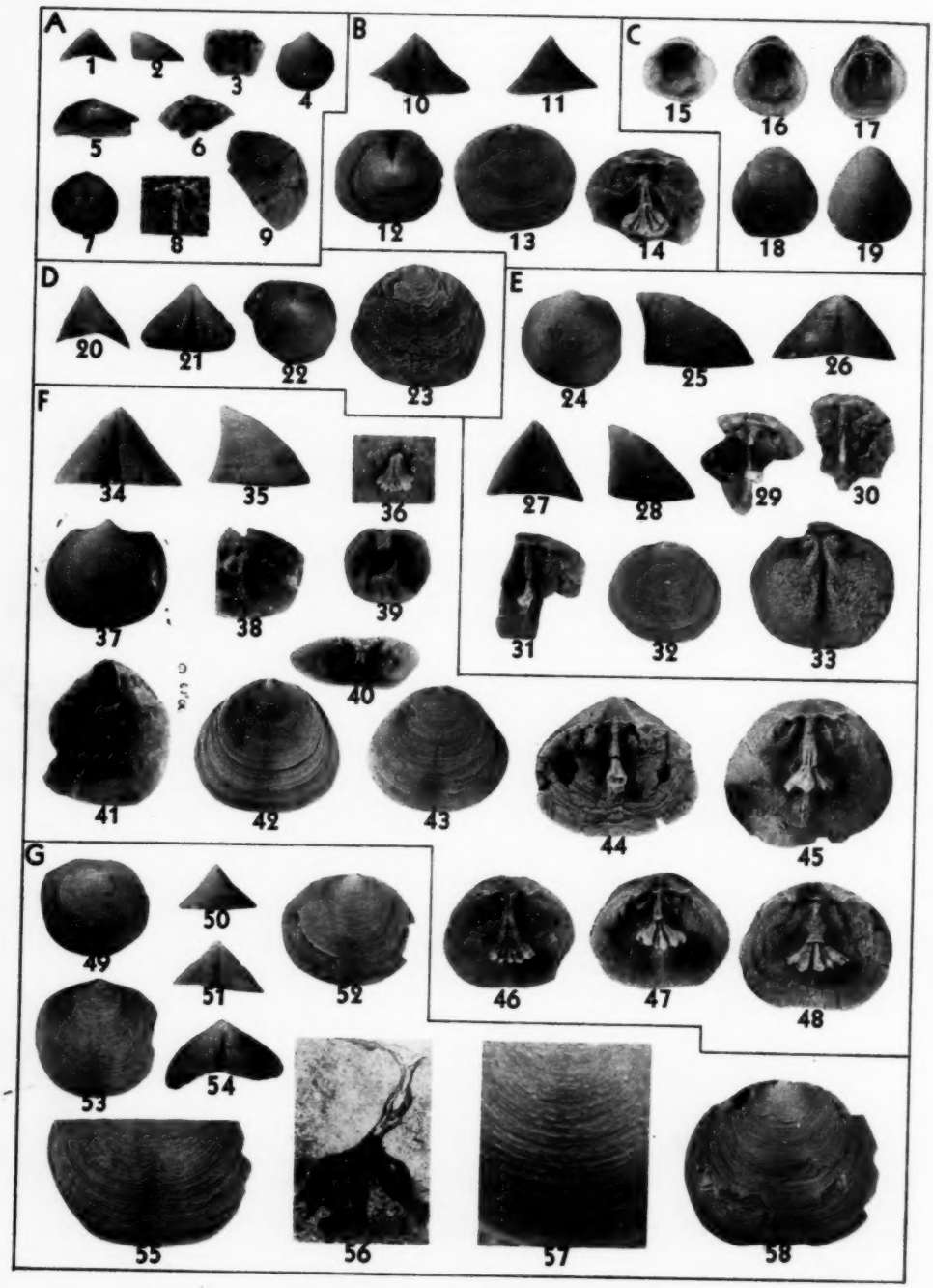
15–18—Acrothele panderi Walcott. *15*, Hypotype; apical view of incomplete mature ventral valve, U.S.N.M. 52002c, ×3, loc. 5j. *16*, Holotype (Mon. 51, pl. 59, fig. 5); apical view of immature ventral valve, U.S.N.M. 52003a, ×4, loc. 4v. *17*, Paratype (Mon. 51, pl. 59, fig. 5a); exterior of strongly sulcate dorsal valve, U.S.N.M. 52003b, ×4, loc. 4v. *18*, Hypotypes; exterior of two slightly sulcate dorsal valves, one of which is partly exfoliated, U.S.N.M. 52002d, ×3, loc. 5j. Middle Cambrian: Gordon shale. (p. 220)

19–26—Homotreta interrupta Bell, n. gen., n. sp. *19*, Syntype; interior of incomplete dorsal valve, showing pseudointerarea and bladelike septum (see text, fig. 2, for profile), Mont. T1194f, ×6, loc. 26-3. *20, 21, 23*, Syntype; lateral, posterior, and apical views of ventral valve with slightly broken apex, Mont. T1194b, ×6, loc. 26-3. *22*, Syntype; exterior of dorsal valve, showing criss-cross pattern of fila in shallow sulcus, Mont. T1194c, ×10, loc. 26-2. *24*, Syntype; posterior view of ventral valve, showing pedicle foramen and deep intertrough, Mont. T1194a, ×10, loc. 26-3. *25*, Syntype; enlarged view of surface of incomplete ventral valve, showing segmented fila, Mont. T1194d, ca. ×20, loc. 26-2. *26*, Syntype; greatly magnified view of thin section of dorsal septum at its highest point (see text fig. 1, for serial sections), Mont. T1194g, ca. ×54, loc. 26-3. Middle Cambrian: "Pagoda" limestone. (p. 230)

27–31—Pegmatreta rotunda Bell, n. gen., n. sp. *27*, Syntype; exterior of dorsal valve, Mont. T1195b, ×6, loc. 26-3. *28, 30*, Syntype; posterior and apical views of crushed ventral valve, showing distinct intertrough, Mont. T1195a, ×6, loc. 26-3. *29*, Syntype; interior of incomplete dorsal valve, showing part of apical pit and low median septum, Mont. T1195d, ×10, loc. 26-3. *31*, Syntype; partial internal mold of dorsal valve, showing impressions of apical pit, obsolete propareas, and median septum, Mont. T1195c, ×6, loc. 26-3. Middle Cambrian: "Pagoda" limestone. (p. 232)



Bell, Cambrian Brachiopoda



Bell, Cambrian Brachiopoda

layers, of which the inner ones are radially banded; pitting of inner layers less distinct than in *D. politus* and *D. occidentalis;* each layer flattened near margin of shell (pl. 29, figs. 5, 7).

Ventral valve: Propareas narrow, not sharply defined; pedicle groove wide, shallow, short. Central portion of valve greatly thickened internally by massive callus deposit, which separates easily from outer shell

EXPLANATION OF PLATE 31

FIGS. *1–9*—"*Acrotreta*" *tetonensis* Walcott. *1, 2, 4*, Hypotype; posterior, lateral, and apical views of ventral valve, Mont. T1199b, ×6, loc. 44-2. *3*, Hypotype; interior of ventral valve, showing strong cardinal muscular scars and deep visceral cavity, Mont. T1199a, ×6, loc. 44-2. *5*, Hypotype; posterior view of ventral valve, showing apical foramen, Mont. T1199f, ×10, loc. 44-2. *6, 8*, Hypotypes; interior of incomplete dorsal valve, and fragment occurring 2.2 mm. from it, presumably part of a dorsal septum, Mont. T1199c–d, ×10, loc. 44-2. *7*, Hypotype; apical view of partly exfoliated ventral valve, showing impression of visceral cavity, Mont. T1199g, ×15, loc. 44-2. *9*, Hypotype; exterior of incomplete dorsal valve, Mont. T1199e, ×10, loc. 44-2. Upper Cambrian: Dry Creek shale. (p. 234)

10–14—*Prototreta subcircularis* Bell, n. sp. *10–12*, Syntype; posterior, lateral, and apical views of ventral valve with slightly broken apex, Mont. T1187a, ×6, loc. 26-4. *13*, Syntype; exterior of dorsal valve, Mont. T1187b, ×6, loc. 26-4. *14*, Syntype; interior of incomplete dorsal valve, Mont. T1187c, ×6, loc. 26-4. Middle Cambrian: Pentagon shale. (p. 228)

15–19—*Linnarssonella elongata* Bell, n. sp. *15, 16*, Syntype; two views of ventral interior, the former tilted so as to show apical cavity, the latter showing strongly apsacline pseudointerarea, Mich. 20811a, ×6, loc. M-14. *17*, Syntype; interior of dorsal valve, showing strongly developed apical platform, short septum, and deep grooves in posterolateral margins for reception of "teeth" in ventral valve, Mich. 20811b, ×6, loc. M1-4. *18, 19*, Syntypes; exteriors of dorsal and ventral valves, Mich. 20811d–e, ×6, loc. M1-4. Upper Cambrian: Snowy Range formation. (p. 235)

20–23—*Prototreta attenuata* (Meek). *20–22*, Hypotype; lateral, posterior, and apical views of incomplete ventral valve, U.S.N.M. 7867d, ×6, loc. 302. *23*, Paratype (Mon 51, pl. 64, fig. 1h); exterior of badly exfoliated dorsal valve, U.S.N.M. 7867c, ×6, loc. 302. Middle Cambrian: Meagher limestone (*Ehmania* zone). (p. 223)

24–33—*Prototreta mimica* Bell, n. sp. *24, 27, 28*, Syntype; apical, posterior, and lateral views of ventral valve, Mont. T1188a, ×6, loc. 47-3. *25, 26*, Syntype; lateral and posterior views of gerontic ventral valve with strongly curved pseudointerarea, Mont. T1188g, ×6, loc. 47-3. *29, 31*, Syntypes; interiors of dorsal valves with expanded septa, Mont. T1188d–e, ×6, loc. 47-3. *30*, Figured specimen; interior of dorsal valve with unexpanded septum, probably the result of secondary reconstruction (see text fig. 13), Mont. T1188h, ×6, loc. 47-3. *32*, Syntype; exterior of dorsal valve, Mont. T1188b, ×6, loc. 47-3. *33*, Syntype; internal mold of dorsal valve, showing impressions of strong muscular scars, Mont. T1188c, ×6, loc. 47-3. Middle Cambrian: Meagher limestone. (p. 226)

34–48—*Prototreta trapeza* Bell. *34, 35, 37*, Paratype; posterior, lateral, and apical views of ventral valve, Mich. 20819a, ×6, loc. M4-4. *38–40*, Paratypes; interior views of three ventral valves, showing high ridge behind intertrough, internal opening of pedicle tube, and deep pallial sinuses, Mich. 20819f–g (×8, loc. M4-4), Mont. T1186a (×6, loc. 45–3a). *41*, Paratype; interior view of anterior slope of ventral valve, showing projecting shell laminae, pallial sinuses, and apical cavity, Mich. 20819d, ×6, loc. M4-4. *42, 43*, Paratypes; exterior views of two dorsal valves, Mich. 20819b–c, ×6, loc. M4-4. *44, 36*, Figured specimen; interior of incomplete dorsal valve exposed by weathering, and part of anterior end of dorsal septum occurring 8 mm. distant on same piece of limestone, Mont. T1191a, ×6, loc. 47–3 loose. *45, 47, 48*, Paratypes; interior of three dorsal valves, showing variations in flabellate septum, and two pairs of cardinal muscular scars in *45*, Mont. T1186c (×6, loc. 45-3), Mich. 20819e (×6, loc. M4-4), Mont. T1186b (×6, loc. 45-3a). *46*, Holotype (Bell, 1938, pl. 1, fig. 4); interior of dorsal valve, Mont. 1535, ×6, loc. 45-3a. Middle Cambrian: Meagher limestone (*Bathyuriscus* zone). (p. 229)

49–58—*Prototreta flabellata* Bell, n. sp. *49–51*, Syntype; apical, lateral, and posterior views of partly exfoliated ventral valve, Mich. 20805a, ×6, loc. M3-2. *52*, Figured specimen; exterior of partly exfoliated dorsal valve, Mont. T1190a, ×10, loc. 43-3a. *53*, Figured specimen; exterior view of dorsal valve, Mont. T1189b, ×6, loc. 45-2. *54*, Figured specimen; posterior view of ventral valve, showing pedicle foramen and narrow intertrough, Mont. T1189a, ×10, loc. 45-2. *55*, Figured specimen; enlarged view of anterior portion of valve in *53*, showing criss-cross pattern in sulcus, and segmentation of fila, Mont. T1189b, ×10, loc. 45-2. *56*, Syntype; greatly magnified view of thin section made at expanded portion of dorsal septum (see text fig. 20, for serial sections), Mich. 20805c, ca. ×54, loc. M3-2. *57*, Figured specimen; enlarged view of middle portion of valve in *52*, showing segmentation of fila, Mont. T1190a, ca. ×30, loc. 43-3a. *58*, Syntype; exterior of partly exfoliated dorsal valve, showing criss-cross pattern of fila in sulcus, Mich. 20805b, ×10, loc. M3-2. Middle Cambrian: Meagher limestone (*Ehmania* zone). (p. 223)

laminae. Musculature not well enough known to warrant description.

Dorsal valve: Propareas not distinct. Central portion of valve thickened internally by massive callus deposit, which separates easily from outer shell laminae; callus concentrated in two wide arcuate ridges, convex toward lateral margins of valve, and bordering a pair of large muscular impressions, presumably the centrals.

Dimensions (mm.)

	Length	Width	L/W
Ventral valve:			
Mont. T1202b....	?	6.1?	
Dorsal valves:			
Mont. T1202a....	5.0?	6.5?	0.77
Mich. 20812a.....	4.8?	6.0?	0.80

Holotype, Mont. T1202a; paratypes, Mont. T1202b–d; figured specimens, Mich. 20812a–b.

Horizon and locality.—Upper Cambrian. Dry Creek shale: *44-2, Crowfoot Ridge;* 46-3, Nixon Gulch; U.S.N.M. localities 151a, Churn Canyon; 152a, Dry Creek; 158, near Hillsdale. Snowy Range formation: M1-4, Beartooth Butte; M2-1, Republic Mt.

Distinguishing characters.—Dicellomus mosaica is characterized by its large size, transversely ovate outline, moderate and subequal biconvexity, and surface ornamentation consisting of minute and closely adjacent pits.

Discussion.—Dicellomus mosaica apparently is very close to *D. pectenoides* (Whitfield) in size and form, but differs in having a pitted surface ornamentation. Most of the specimens from Montana that Walcott assigned to *D. pectenoides* are *D. mosaica.*

DICELLOMUS OCCIDENTALIS Bell, n. sp.
Plate 29, figures 18–23

Dicellomus politus (Hall). WALCOTT (part), 1912, U. S. Geol. Survey, Mon. 51, pl. 52, fig. 3.

Outline of ventral valve slightly elongate subtrigonal, greatest width being about 0.6 length of valve from apex; outline of dorsal valve slightly transverse subtrigonal to ovate, greatest width being slightly less than 0.6 length of valve from apex; profile strongly dorsi-biconvex, greatest convexity near middle of ventral valve and in posterior third of dorsal valve; surface usually glossy, smooth except for very subdued and indistinct growth ridges; shell thick, composed of several laminae, of which the inner ones are radially banded and distinctly pitted; each layer abruptly flattened at margin of shell, conspicuous on partly exfoliated valves (pl. 29, figs. 19, 21).

Ventral valve: Interior like that of *D. politus* (Hall), so far as can be determined; cardinal muscular scars large, deep; composite central scar borders each side of spatulate visceral area near its anterior end.

Dorsal valve: Interior similar to that of *D. politus;* pedicle furrow shallow; posterolateral grooves, as described for *D. politus* (Walcott, 1912, p. 577), not observed; cardinal muscular scars large, apparently composite; central scars large, elongate, near middle of valve, and separated by a low ridge; anterior lateral scars small, elongate, between and nearly in contact with anterior ends of central scars.

Dimensions (mm.)

	Length	Width	L/W
Ventral valves:			
Mont. T1200b....	5.1	5.0	1.02
Mont. T1200e....	5.8	5.75	1.01
Dorsal valves:			
Mont. T1200a....	4.1	4.5	0.91
Mont. T1200d....	4.5	5.0	0.90

Syntypes, Mont. T1200a–f.

Horizon and locality.—Upper Cambrian. Lower Pilgrim limestone: *32-3, Belt Creek;* 33-1 (?), 33-2, Keegan Butte; 38-3, Dry Wolf Creek. Limestone lenses in upper Park shale: 38-1, Dry Wolf Creek; 41-3, Big Snowy Mountains. Lower Pilgrim limestone or limestone lenses in upper Park shale: U.S.N.M. localities 5k (2), head of Sawmill Creek; 302k, near Gallatin.

Distinguishing characters.—Dicellomus occidentalis is characterized by its subequal length and width, dorsi-biconvexity, abrupt outward flexing of shell layers to form a flat marginal brim, and by having the dorsal anterior lateral muscular scars nearly in contact with the central scars.

Discussion.—Dicellomus occidentalis differs from *D. politus* (Hall) in having a less elongate and acuminate ventral valve, a more transverse and convex dorsal valve, the dorsal valve being more convex than the ventral, and in the position of the dorsal anterior lateral muscular scars.

The type specimens of *D. nanus* (Meek and Hayden) from the Black Hills of South

Dakota, although so poorly preserved as to be almost useless for comparison, seem to be closer to *D. politus* than to *D. occidentalis*. Walcott's (1912, p. 573, pl. 53, figs. 1, 1a–l) presentation of *D. nanus* was based on excellently preserved specimens from the Bighorn Mountains, Wyoming, which may not belong to *Dicellomus;* the shell is evidently composed of only one thick layer, instead of being made up of numerous radially banded laminae as in the genotype of *Dicellomus*.

Genus ACROTHELE Linnarsson, 1876
ACROTHELE CLARKI (Walcott)
Plate 30, figures 4–7

Dearbornia clarki WALCOTT, *1908*, Smithsonian Misc. Coll., vol. 53, no. 3, p. 78, pl. 8, fig. 7;—*1912*, U. S. Geol. Survey, Mon. 51, p. 614, pl. 82, figs. 7, 7a–d.

Walcott's assignment of this species to a new genus, *Dearbornia*, was unquestionably the result of his interpretation of the shell substance as being calcareous. The original collection comprises the only specimens of the species known, but a restudy of them forces the conclusion that the shell material was calcareocorneous. There are no "semiphosphatic shells of *Obolus*" (Walcott, 1912, p. 614) associated with the type specimens in the coarsely oolitic limestone matrix. The holotype, a ventral internal mold, has at the apex a remnant of the original shell, enclosing a mold of the interior of the pedicle tube (pl. 30, fig. 6). The fragment is black, hard, and glossy, being typical of the shell substance of *Acrothele*. Most of the specimens obviously are internal molds; in a few individuals the original shell apparently was dissolved, and the resulting cavity filled with calcite. Probably it was these specimens on which Walcott based his interpretation of a calcareous shell.

The internal molds reveal a morphology congeneric with *Acrothele*. In the dorsal valve there is clearly indicated an umbonal thickening and two narrow ridges extending anterolaterally from it (pl. 30, fig. 5). The ventral valve possesses the short pedicle tube and strong pallial trunks characteristic of the genotype and other species of *Acrothele*.

Acrothele clarki cannot be adequately compared with other species of *Acrothele* from Montana, but it appears to differ from all of them in being smaller, more elongate in outline, and in having the ventral apex near er the posterior margin.

Dimensions (mm.)

	Length	Width	L/W
Ventral valves:			
U.S.N.M. 52214a.	3.0	3.0	1.00
U.S.N.M. 52214c.	5.25	5.25	1.00
Dorsal valve:			
U.S.N.M. 52214d.	4.0	3.9	1.03

Holotype, U.S.N.M. 52214a; paratypes, U.S.N.M. 52214b–d.

Horizon and locality.—Middle Cambrian. U.S.N.M. loc. 9k, Dearborn Canyon section; exact stratigraphic position unknown, possibly Damnation limestone.

ACROTHELE COLLENI Walcott
Plate 30, figures 1–3

Acrothele colleni WALCOTT (part), *1912*, U. S. Geol. Survey, Mon. 51, p. 640, pl. 63, figs. 6, 6a–b (not text figs. 55A–E, p. 641); WALCOTT (part), 1917, Smithsonian Misc. Coll., vol. 67, no. 2, pl. 4, figs. 5d–f.

Outline probably subcircular, with posterior margin of ventral valve slightly truncated; growth ridges on surface irregularly spaced, faint to rugose; entire surface covered by minute, irregular, inosculating ridges, bearing papillae on their crests. Shell calcareocorneous, laminated, thick.

Ventral valve: Profile triangular, height excessive for the genus; apex slightly posterior to middle of shell, bluntly rounded, bearing a pair of elongate tubercles on well-preserved valves; foramen elongate-elliptical, situated posterior to apex; posterior slope flattened, surface of apical half granular, that of marginal half smooth. Interior has a low tubercle, its lateral surface concave, on either side of median line about middle of posterior slope; low projecting ridge or collar constricts small apical chamber.

Dorsal valve: Apex marginal, minute, depressed, formed by two elongate tubercles; umbo convex, with broad and deep basinlike preumbonal depression; anterior two-thirds of valve flat or slightly convex. Interior unknown.

Holotype, U.S.N.M. 51973a; paratypes, U.S.N.M. 51973b–c; hypotype, U.S.N.M. 51973d.

Horizon and locality.—Middle Cambrian. Gordon shale: U.S.N.M. loc. 4q, ridge between Gordon and Youngs Creeks.

Distinguishing characters.—*Acrothele col-*

	Dimensions (mm.)				
	Length	Width	Height	L/W	H/W
Ventral valve:					
U.S.N.M. 51973b		6.5	2.2?		0.34
Dorsal valve:					
U.S.N.M. 51973d	7.0	7.0		1.00	

leni is characterized by its excessively high, subconical ventral valve and by the large preumbonal depression in the dorsal valve.

Discussion.—The holotype, a ventral valve, is so badly damaged that a better preserved paratype (Walcott, 1912, pl. 63, fig. 6a) is refigured in this paper (pl. 30, figs. 1–2). The dorsal valve illustrated by Walcott (1912, pl. 63, fig. 6b) is an external impression that does not show the apex clearly; an associated valve, a hypotype, is figured in this paper (pl. 30, fig. 3).

Acrothele colleni is readily distinguished from all other species of *Acrothele* in Montana by its high ventral valve and preumbonally depressed dorsal valve. The specimens from British Columbia and Alberta (Walcott, 1912, pp. 641–42) do not belong to this species.

Some ventral valves suggest that the marginal half of the posterior slope is bulged into a "homoeodeltidium," much like that in *Micromitra sculptilis* (Meek), but this condition may be the result of crushing. Slots in the posterior margin of a paratype (pl. 30, figs. 1–2) may be of secondary origin, although their bilaterality suggests that they may be primary structures.

Acrothele panderi Walcott
Plate 30, figures 15–18

Acrothele panderi Walcott, *1912*, U. S. Geol. Survey, Mon. 51, p. 651, pl. 59, figs. 5, 5a–c.

Outline subcircular to transversely subelliptical; growth ridges faint to moderately strong, unequally spaced; entire surface covered by closely spaced coarse granules; shell calcareocorneous, laminated, moderately thick.

Ventral valve: Profile obtusely trigonal; apex low, formed by two elongate tubercles, situated close to posterior margin in young individuals, nearer to middle third of valve in mature specimens; foramen elongate elliptical, situated posterior to apex; pseudointerarea modified by triangular, smooth, slightly convex portion occupying marginal two-thirds of slope, and bounded by abrupt flexure of fila along two lines, which diverge posteriorly at an angle of about 45°. Interior unknown.

Dorsal valve: Outline somewhat subquadrate as result of slight straightening of anterior and posterior margins; profile very slightly convex; apex marginal, minute, depressed, formed by two elongate tubercles; sulcus distinct or vague, deeper and wider toward margin of valve, usually with low secondary ridges on floor. Interior with umbonal callosity, from which two subarcuate ridges extend anterolaterally. This structure is like that in *A. pentagonensis* but less strongly developed (compare pl. 30, fig. 18, and pl. 30, fig. 9).

	Dimensions (mm.)		
	Length	Width	L/W
Ventral valves:			
U.S.N.M. 52003a	3.2	3.4	0.94
U.S.N.M. 52002c	8.3?	10.0?	0.83
Dorsal valves:			
U.S.N.M. 52003b	4.0	4.5	0.89
U.S.N.M. 52002d	8.0	8.5?	0.94

Holotype, U.S.N.M. 52003a; paratypes, U.S.N.M. 52003b, 52002a–b; hypotypes, U.S.N.M. 52002c–d.

Horizon and locality.—Middle Cambrian. Gordon shale: U.S.N.M. localities *4v, Gordon Creek;* 5j, Scapegoat Mountain.

Distinguishing characters.—*Acrothele panderi* is characterized by its coarsely granular surface, sulcate dorsal valve, and very low ventral valve.

Discussion.—*Acrothele panderi* apparently is most similar to *A. pentagonensis*, but differs distinctly from it in having a dorsal sulcus and a coarsely granular surface.

The holotype of *A. panderi* evidently is an immature individual. The revised description of the species is based primarily on large ventral valves from a locality not far distant from the type locality. The dorsal sulcus is a somewhat variable feature, although always present. Valves with distinct and indistinct sulci are present at both localities from which the species is known. Most of the dorsal valves from locality 5j are

cracked longitudinally at the apex, which accounts for the linear ridge visible on the internal molds. No ventral interiors were found by the writer in the collections at the United States National Museum, and consequently the characters described by Walcott (1912, p. 651) could not be verified.

ACROTHELE PENTAGONENSIS Bell, n. sp.
Plate 30, figures 8–10

Outline subcircular; growth ridges strong, irregularly spaced, distinctly more rugose towards margin of shell; entire surface covered by irregularly undulating and broken threadlike elevations, bearing numerous minute papillae upon their crests. Shell calcareocorneous, laminated, thick.

Ventral valve: Profile obtusely trigonal; pseudointerarea straight, about 55° procline, approximately one-third length of gently concave anterior slope; pseudointerarea smooth, except for growth ridges, and indistinctly bounded by abrupt flexing of growth ridges along two lines, which diverge from foramen at about 60°; triangular fold on anterior slope produced by several low ridges, which radiate from apex, widen, and partly fuse toward margin of valve; angle of divergence between two lateral ridges about 45°; apex rounded, formed by two large round tubercles; foramen large, elongate-elliptical, situated posterior to apex. Interior unknown.

Dorsal valve: Profile gently convex, greatest convexity slightly anterior to apex; apex marginal, depressed, formed by two large elongate tubercles. Interior with small crenulated space at apex, probably for muscular attachment; strong umbonal thickening present, extends anteriorly as a low narrow ridge, which forks around a short median furrow (muscular scar), the two prongs disappearing opposite middle of furrow; umbonal thickening extended anterolaterally as two short ridges, which are concave outwardly (pl. 30, fig. 9).

Dimensions (mm.)

	Length	Width	L/W
Dorsal valve:			
Mont. T1196b....	9.0?	10.0	0.90

Syntypes, Mont. T1196a–c.

Horizon and locality.—Middle Cambrian. Pentagon shale: 26-4, Lick Creek.

Distinguishing characters.—*Acrothele pentagonensis* is characterized by its triangular ventral fold, smooth ventral pseudointerarea, and surface ornamentation.

Discussion.—*Acrothele pentagonensis* resembles *A. panderi* to some degree but differs from it in having a ventral fold and in not having a dorsal sulcus. Also, the surface ornamentation in the two species is quite different. *A. pentagonensis* resembles rather closely *A. asiatica* Resser and Endo (1937, p. 128, pl. 25, figs. 6–10) from the Mapan formation of southern Manchoukuo, but, so far as can be determined from a comparison of their morphology, appears to be specifically different.

A. panderi and *A. colleni* differ from *A. pentagonensis* in having the apical third of the posterior slope (pseudointerarea) granulated in the same manner as the general surface of the shell, and in having the marginal two-thirds smooth. The significance of this difference is not known.

Genus PROTOTRETA Bell, 1938

Prototreta BELL, *1938*, Michigan Acad. Sci., Papers, vol. 23, p. 405.

Outline subcircular, subtrapezoidal, or transversely subelliptical; ventral valve conical, dorsal valve slightly convex; anterior commissure rectimarginate or sulcate; shell minute, calcareocorneous, laminated, surface filate.

Ventral valve: Posterior margin indented at midpoint; profile subtriangular; pseudointerarea procline to apsacline, depressed at center, forming a trough (intertrough) which widens and deepens from apex to margin of valve; bottom of trough characterized by a flattened granular area, extending from foramen to commissure; foramen circular, situated posterior to apex. Shell laminae in apical portion of valve project into interior, forming an imperfect "cone-in-cone" structure; pedicle tube has internal opening at about midpoint of a low ridge, which extends from apex to center of posterior margin; deep pit, from which a narrow pallial sinus extends anterolaterally, occurs on either side of ridge, opposite opening of pedicle tube.

Dorsal valve: Apex minute, marginal, grooved at summit, extended beyond margin of ventral valve; sulcus present or ab-

sent. Posterolateral margins thickened into nearly flat, anacline propareas, which border a broad central groove whose margins diverge anteriorly from apex at about 90°, prominent median septum expands anteriorly into a plate, from which extend finger-like projections; a pair of small muscular scars adjoins posterior end of septum; each large scar of a pair lateral to the first is elongated in line with margin of apical groove; a possible third pair occurs on floor of valve adjoining expanded portion of septum.

Genotype, *Prototreta trapeza* Bell, 1938.

Distinguishing characters.—The most characteristic structure possessed by this genus is the flabellate dorsal septum. The "cone-in-cone" character of the ventral valve, the troughlike ventral pseudointerarea with its central granular floor, the circular foramen posterior to the apex, and the triangular dorsal propareas further distinguish *Prototreta* from all other described genera.

Discussion.—*Prototreta* belongs to a large group of species that have been assigned, on the basis of external similarity, to the genus *Acrotreta* Kutorga. The writer (1938, p. 403) has discussed somewhat at length the status of *Acrotreta* and the reasons for separating new genera from it. Briefly, the internal characters of the genotype, an Ordovician species from the Baltic region, are unknown. Because it appears that several generic groups are included among the species now assigned to *Acrotreta*, it is desirable to describe these groups and determine their relationship to *Acrotreta* s.s. when the internal characters of the latter are made known.

The internal characters of most American species of "*Acrotreta*" are unknown, and consequently their generic status is in doubt. Until the anatomy of these so-called species of *Acrotreta* are known, little can be said regarding the systematic relationships of *Prototreta*. However, a few of the characters of *Prototreta* which may be important in the determination of generic relationship should be emphasized.

The thin laminae of the shell of *Prototreta* project into the interior of the ventral valve, simulating an incomplete "cone-in-cone" structure (pl. 31, fig. 41; text figs. 7, 15, 18). Because the inner ends of the laminae are embedded in matrix, any attempt to exfoliate the shell in order to obtain an internal mold is unsatisfactory. Some valves can be cleaned with a needle, but the more delicate inner extensions of the laminae are destroyed, and with them any pallial or muscular markings that they may possess. This extreme development of a "cone-in-cone" structure is not apparent in any described species of "*Acrotreta*" seen by the writer, although a few appear to possess it to a slight degree in the apical portion of the valve.

The so-called "false pedicle groove" on the posterior slope of the ventral valve almost certainly was unrelated to the functional pedicle, but it may represent the growth track of the internal pedicle tube during development of the valve. The term *intertrough* is proposed for this furrow, which depresses the posterior slope from the apex to the commissure in many acrotretoid brachiopods. So far as can be observed, no opening was present between the valves at the cardinal margin. Evidently a thickened projection of the ventral valve fitted into the apical groove in the dorsal valve.

The type of dorsal pseudointerarea characteristic of *Prototreta* apparently has not been described in the literature, but a study of several species of "*Acrotreta*" suggests that careful preparation may reveal its presence. Seemingly the strongly anacline propareas, which extend into the ventral valve, would prohibit any pronounced lateral sliding of the valves over each other, such as is generally thought to occur among the "inarticulate" brachiopods. The median groove which simulates the ventral pedicle groove of certain atremate brachiopods, appears to have been the seat of muscular implantation. The markings in the groove, together with the faint median ridge, produce a structure analogous, if not homologous, with that in some articulate brachiopods which do not possess a cardinal process.

The flabellate dorsal septum, the most characteristic structure of *Prototreta*, apparently is unique among brachiopods. Considerable variation, even within the same species, is apparent (pl. 31, figs. 45–48), but because the septum can be completely exposed only under very favorable conditions, and even then at the expense of considerable time, no systematic study of the structure

could be undertaken. The function of the septum is a matter of speculation. Schuchert[6] and Cooper[6] believe it to be the seat of muscular attachment. This appears to be the best explanation, even though muscular scars have not been observed on the septum. The septum in *P. trapeza* and *P. subcircularis* is much stronger and apparently more specialized than it is in the somewhat earlier *P. flabellata* and *P. mimica*.

Muscular scars have been positively identified on the floor of the valve adjacent to the propareas. One pair of small scars adjoins the posterior end of the septum, and two larger scars, lateral to the first, diverge anterolaterally almost in line with the margins of the apical groove. A third pair of questionable muscular impressions adjoins the septum near its middle. Although the points of insertion of some of the muscles are known, no statement can be made regarding the arrangement of the muscles and their operation.

PROTOTRETA ATTENUATA (Meek)
Plate 31, figures 20–23

Acrotreta attenuata MEEK, U. S. Geol. and Geog. SurveyTerr., Sixth Ann. Rept. p. 463, footnote; WALCOTT (part), *1912*, U. S. Geol. Survey, Mon. 51, p. 675, pl. 64, figs. 1, 1a, 1h (not figs. 1b–g = *Prototreta flabellata* Bell, n. sp.; figs. 1i–o).

Acrotreta attenuata var.? WALCOTT, *1905*, U. S. Nat. Mus., Proc., vol. 28, p. 298; *1912*, U. S. Geol. Survey, Mon. 51, p. 676, pl. 65, fig. 2.

This species is not represented in the writer's collections, the present discussion being based on the type lot of specimens preserved in the United States National Museum.

The apex of the holotype (Walcott, 1912, pl. 64, fig. 1), a ventral valve, is broken, and most of the shell has been exfoliated from the pseudointerarea. The growth lines are similar to those on *Prototreta trapeza*, perhaps slightly more distinct and regular, except that they are crinkled into a "criss-cross" pattern along the midline of the anterior slope. A nearly complete ventral valve (Walcott, 1912, pl. 64, fig. 1a) shows all the external characters of *Prototreta* and is unquestionably conspecific with the holotype but does not have the crinkled growth lines on the anterior slope. A third valve (Walcott, 1912, pl. 64, fig. 1h), a dorsal, gives little information other than the outline. A single ventral valve from the same locality was identified by Walcott (1912, p. 676, pl. 65, fig. 2) as *Acrotreta attenuata* var.?, but it appears not to be distinct from the species. Three other lots of specimens, almost certainly from the type locality but not numbered, contain several nicely preserved ventral valves of "*Acrotreta*" *attenuata*, one ventral valve of *Prototreta flabellata*, and two dorsal valves referred to *Prototreta flabellata*. In addition, specimens of *Micromitra* and "*Lingulella*" too poorly preserved to be specifically determined and a single pygidium of *Ehmania*, are present. The aspect of the fauna places it in the basal Meagher *Ehmania* zone, but *Prototreta attenuata* does not occur in any of the writer's collections from that zone.

Because the dorsal valve figured by Walcott (1912, pl. 64, fig. 1h) is the only one known, and because it does not give information of the interior, the present assignment of this species to *Prototreta* cannot be definitely proved. However, the information revealed by the ventral valves alone seems sufficient to make the assignment with considerable confidence.

Prototreta attenuata is characterized by its sharply pointed apex, straight pseudointerarea, and strongly concave slope slightly anterior to the apex.

Holotype, U.S.N.M. 7867a; paratypes, 7867b–c; hypotype, 7867d.

Horizon and locality.—Middle Cambrian. Meagher limestone (*Ehmania* zone?): U.S. N.M. loc. 302, east side of West Gallatin River, above Gallatin.

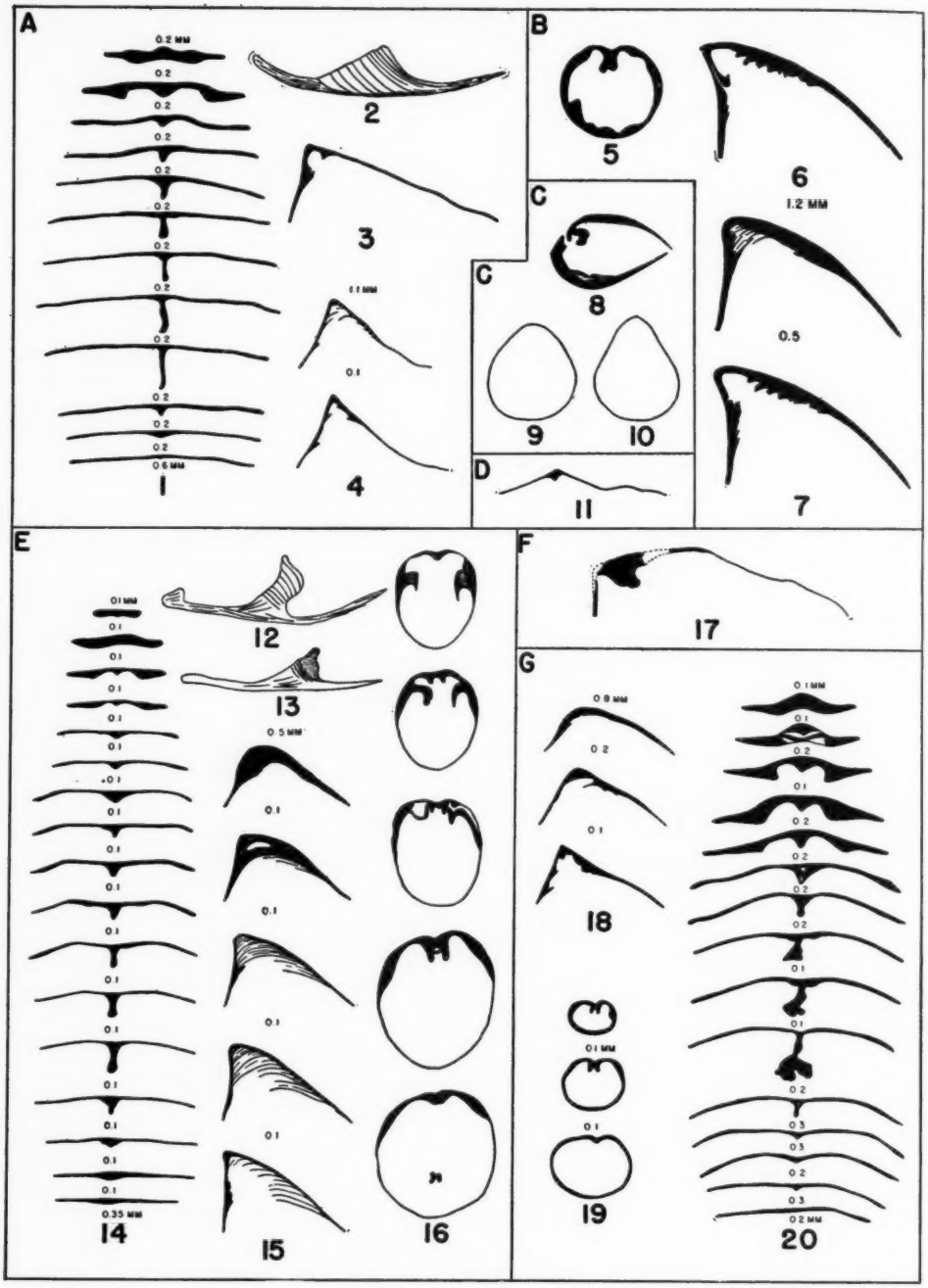
PROTOTRETA FLABELLATA Bell, n. sp.
Plate 31, figures 49–58;
text figures 18–20

Outline subcircular or transversely subel-

[6] Personal communications.

Dimensions (mm.) of Prototreta attenuata

	Length	Width	Height	L/W	H/W
Ventral valve:					
U.S.N.M. 7867d	2.0?	2.25?	1.6	0.89	0.71
Dorsal valve:					
U.S.N.M. 7867c	2.9	3.17		0.91	



FIGS. 1–20.—Cross sections of Cambrian Brachiopoda. For detailed explanation see opposite page.

liptical; ventral valve conical and lower than average for genus; dorsal valve slightly convex and gently sulcate; fila strong, regular, rounded, usually continuous, but segmented on the marginal portions of some valves (pl. 31, fig. 57).

Ventral valve: Posterior margin indented at base of intertrough, anterior margin straight or slightly emarginate; profile subtriangular; pseudointerarea straight, 10°–20° procline; anterior slope straight or gently convex, often tending to be slightly concave near apex; intertrough wider and deeper at commissure than at foramen, and characterized by medial, well-defined, distinctly depressed and flattened granular area, the sides of which tend to be subparallel; foramen circular, about 0.03 mm. in diameter, and situated slightly posterior to apex; fila flex apically along margins of posterior gran-

EXPLANATION OF TEXT FIGURES 1–20

FIGS. *1–4—Homotreta interrupta* Bell, n. gen., n. sp. *1*, Syntype; serial sections from apex to anterior margin of dorsal valve, showing bladelike septum (see pl. 30, fig. 26, for photograph of thin-section taken at highest point of septum), Mont. T1194g, loc. 26-3. *2*, Syntype; profile of dorsal septum, showing trend of growth lines, Mont. T1194e, loc. 26-3. *3*, Syntype; section through longitudinal midplane of ventral valve, Mont. T1194h, loc. 26-3. *4*, Figured specimen; sections parallel to longitudinal midplane of ventral valve, unnumbered specimen, loc. 26-2. Middle Cambrian: "Pagoda" limestone. (p. 230)

5–7—Prototreta trapeza Bell. *5*, Paratype; cross section through ventral valve, taken parallel to commissure and about at middle of posterior slope, showing high internal ridge behind intertrough (see pl. 31, fig. 39, for specimen from which drawing was made), Mich. 20819g, loc. M4-4. *6*, Theoretical composite cross section along longitudinal midplane of ventral valve, showing probable trend of pedicle tube. *7*, Paratype; longitudinal sections through ventral valve, showing "cone-in-cone" structure of shell laminae (lower section is along midline of valve), Mich. 20819h, loc. M4-4. Middle Cambrian: Meagher limestone (*Bathyuriscus* zone). (p. 229)

8–10—Linnarssonella elongata Bell, n. sp. *8*, Syntype; drawing of thin section taken parallel to longitudinal axis of complete specimen, but slightly to one side, showing structure for articulation (ventral valve below), Mich. 20811c, loc. M1-4. *9*, *10*, Syntypes; outlines of dorsal and ventral valves shown, respectively, on pl. 31, figs. 18 and 19, Mich. 20811d–e, loc. M1-4. Upper Cambrian: Snowy Range formation. (p. 235)

11—Pegmatreta perplexa Bell, n. gen., n. sp. Figured specimen; longitudinal section along midplane of ventral valve, showing thickened apex (posterior margin at left), unnumbered specimen, loc. M4-4. Middle Cambrian: Meagher limestone (*Bathyuriscus* zone). (p. 232)

12–16—Prototreta mimica Bell, n. sp. *12*, Syntype; longitudinal profile of expanded type of dorsal septum, drawn from thin section (trend of growth lines represented diagrammatically), Mont. T1188f, loc. 47-3. *13*, Figured specimen; profile of an unexpanded septum, probably the result of secondary inorganic growth of a broken expanded type of septum, drawn from specimen shown on pl. 31, fig. 30 (trend of growth lines represented diagrammatically; stippled portion composed of translucent homogeneous calcite), Mont. T1188h, loc. 47-3. *14*, Figured specimen; serial sections from apex to anterior margin of dorsal valve, showing what appears to be an unexpanded septum, a condition that may be the result of breakage of an expanded septum during fossilization, unnumbered specimen, loc. 47-3. *15*, Figured specimen; serial sections through a ventral valve parallel to the longitudinal axis and perpendicular to the commissure, showing "cone-in-cone" structure of the shell laminae (bottom section through midplane of valve), unnumbered specimen, loc. 47-3. *16*, Figured specimen; sketches of a series of sections through a ventral valve parallel to commissure, showing high internal ridge behind intertrough, with pedicle tube within it; bottom sketch shows highest portion of expanded septum in dorsal valve of the complete specimen (distance between sections unknown), unnumbered specimen, loc. 47-3. Middle Cambrian: Meagher limestone. (p. 226)

17—Pegmatreta rotunda Bell, n. gen. n. sp. Syntype; drawing of a thin section along longitudinal midplane of ventral valve, showing greatly thickened apex and trend of growth lines, Mont. T1195e, loc. 26-3. Middle Cambrian: "Pagoda" limestone. (p. 232)

18–20—Prototreta flabellata Bell, n. sp. *18*, Figured specimen; serial sections through ventral valve parallel to longitudinal axis and perpendicular to commissure (bottom section along midplane of valve), unnumbered specimen, loc. M4-3. *19*, Figured specimen; serial sections through a ventral valve parallel to commissure, showing high internal ridge behind intertrough, with pedicle tube within it, unnumbered specimen, loc. M4-3. *20*, Syntype; serial sections from apex to anterior margin of dorsal valve, showing flabellation of expanded septum (see pl. 31, fig. 56, for photograph of thin section made at point of greatest expansion of septum), Mich. 20805c, loc. M3-2. Middle Cambrian: Meagher limestone (*Ehmania* zone). (p. 223)

ular groove, often crinkled slightly on each flank of intertrough along a line from apex to posterolateral commissure. Interior apparently similar to that of *P. trapeza*, so far as can be determined.

Dorsal valve: Posterior margin slightly depressed at midpoint; apex marginal, with minute longitudinal groove or pit at summit, and projecting slightly beyond margin of ventral valve; umbo swollen, sharply raised above surfaces lateral to it; profile evenly and gently convex; anterior margin somewhat straightened, broadly and gently sulcate; fila in bottom of sulcus of most specimens bent toward apex, broken, and crinkled into a "criss-cross" pattern (pl. 31, fig. 55). Interior varies from that of *P. trapeza* only in minor respects; pseudointerarea typically somewhat narrower than that in the genotype, the margins of apical groove diverging at more than 90°; median septum similar, but expanded plate and projecting processes smaller and more delicate and consequently badly distorted or broken in fossilized valve; cardinal muscular scars deeply incised in most valves.

Dimensions (mm.) of Prototreta flabellata

	Length	Width	Height	L/W	H/W
Ventral valve:					
Mich. 20805a	2.25	2.6	1.17	0.87	0.45
Dorsal valves:					
Mich. 20805b	2.4	2.75		0.87	
Mont. T1189b	2.75	3.0?		0.92	
Mont. T1190a	1.6	1.9		0.84	

Syntypes, Mich. 20805a–c; figured specimens, Mont. T1189a–b, T1190a.

Horizon and locality.—Middle Cambrian. Meagher limestone (*Ehmania* zone): 43-3a, Crowfoot Ridge; 45-2, M4-3, Nixon Gulch; *M3-2, Pole Creek;* U.S.N.M. localities 4n, head of Jackson Creek, Teton Mountains, Wyoming; 9h, Beaver Creek; 156a, near Hillsdale; 159, north of West Gallatin River.

Distinguishing characters.—*Prototreta flabellata* is characterized by its low, conical ventral valve, straight ventral pseudointerarea, strong rounded fila (segmented in some individuals), and delicate expanded dorsal septum.

Discussion.—Most of the specimens of *P. flabellata* were found in limestone and their internal morphology was studied principally from serial sections (text figs. 18–20). Some specimens from Nixon Gulch occur in a very soft shale, in which valves are fragmental and badly crushed. So far as can be ascertained, the species is very similar internally to *P. trapeza*, although apparently the structures in *P. flabellata* are somewhat more primitive and subject to greater individual variation. (See section on Homoeomorphy, p. 197, for discussion of *P. flabellata* and *Homotreta interrupta*.)

PROTOTRETA MIMICA Bell, n. sp.
Plate 31, figures 24–33;
text figures 12–16

Outline subcircular or transversely subelliptical; ventral valve sharply conical and high relative to its width; dorsal valve slightly convex and faintly sulcate; surface finely and closely filate, the fila blending laterally and longitudinally with adjoining fila; shell calcareocorneous, laminated, thin.

Ventral valve: Posterior margin gently indented at base of intertrough; profile subtriangular; pseudointerarea catacline, straight to strongly concave, with apex projecting distinctly beyond posterior margin; anterior slope more or less evenly convex, sometimes concave just anterior to apex; intertrough slightly wider and deeper at commissure than at foramen, its floor scarcely flattened, and characterized by strengthening and fusion of fila; foramen minute and inconspicuous, situated on posterior face of sharply pointed apex; fila flexed apically and enlarged by fusion on sides of intertrough. Interior essentially as in *P. trapeza*, except that "cone-in-cone" lamellar structure is developed in all but marginal part of valve (text fig. 15), and posterior median ridge is not as strong.

Dorsal valve: Posterior margin slightly depressed at midpoint; apex marginal, with minute longitudinal groove or pit at summit, and projecting slightly beyond margin of ventral valve; umbo swollen, slightly raised above surfaces lateral to it; profile nearly flat or slightly convex; anterior margin of

most specimens gently sulcate; sulcus broad and shallow, disappearing before reaching apex; fila crossing sulcus without interruption. Interior like that of *P. trapeza* except for configuration of median septum; septum strong and bladelike, and in anterior third of valve spreading into a short, transverse, rodlike plate with projecting processes.

	Dimensions (mm.)				
	Length	Width	Height	L/W	H/W
Ventral valves:					
Mont. T1188a	2.1	2.4	1.7	0.88	0.71
Mont. T1188g	2.7	3.0	1.8	0.90	0.60
Dorsal valves:					
Mont. T1188b	2.4	2.7		0.89	
Mont. T1188c	3.0	3.4		0.88	

Syntypes, Mont. T1188a–g; figured specimen, Mont. T1188h.

Horizon and locality.—Middle Cambrian. Lower Meagher limestone: 47-3, Beaver Creek.

Distinguishing characters.—*Prototreta mimica* is characterized by its subcircular outline, high ventral valve with predominantly evenly convex anterior slope, uninterrupted fila in a faint dorsal sulcus, and dorsal septum expanded abruptly into a transverse rodlike plate.

Discussion.—*Prototreta mimica* differs from *P. trapeza* in outline, configuration of the dorsal septum, and in the absence of crinkled growth lines in the shallow dorsal sulcus; from *P. attenuata*, so far as can be determined, only in the lateral profile of the ventral valve.

The validity of the assignment of this species to *Prototreta* is dependent on whether the species is characterized by an expanded septum, i.e., one in which a transverse plate with anteriorly projecting processes is developed, or an unexpanded septum, i.e., one which consists of a simple vertical plate. Evidence has been observed for the presence of both types of septa, but the writer hopes in the following discussion to demonstrate that the evidence for an unexpanded septum is subject to serious question.

The investigation of the internal morphology of this species was hampered by an insufficient number of dorsal valves, all of which were embedded in a particularly untractable, nearly lithographic limestone matrix. They seem to be identical externally, but serial sections and prepared interiors reveal what appear to be two types of internal septa. Two prepared valves (pl. 31, figs. 29, 31) show a narrow bladelike septum, which spreads abruptly into a transverse rodlike plate with projecting processes in the anterior third of the valve. A specimen (text fig. 16) in which the valves were joined as in life also revealed an expanded type of septum when sectioned. In contrast to the preceding three specimens, a single prepared dorsal valve (pl. 31, fig. 30; text fig. 13) possesses a simple vertical septum, which projects anteriorly as a single spike. Two serial sections (text fig. 14) likewise seem to show unexpanded septa, but the evidence from these sections must be accepted cautiously because, although the presence of features in the sections is proof of their presence in the valves, their absence from the sections proves only their absence from the valves at the time the sections were made and does not indicate whether that absence is the result of nondevelopment of the feature, or the result of subsequent removal of it through damage to the valve. The possibility of losing critical features in the spaces (0.1 mm.) between sections must not be overlooked.

As the presence or absence of an unexpanded septum in *P. mimica* cannot be proven from the two serial sections, the solution of the question rests on the evidence from the prepared dorsal valve (pl. 31, fig. 30) mentioned above. However, examination of this specimen under high magnification indicates that the septum has been altered subsequent to its original formation. The posterior part of the septum (text fig. 13) is composed of black opaque shell material like that forming the septa in the other two prepared dorsal valves of *P. mimica*. The anterior part, including the projecting spike, is translucent and apparently homogeneous in its physical composition, showing no lines of growth as have been observed in other septa of *P. mimica* (text fig. 12) and in

Homotreta interrupta (text fig. 2). To the writer it appears not to be a part of the original septum, but a later accretion of inorganic origin. Petrographic examination of the shell material in *Prototreta* and *Homotreta* shows it to be almost entirely secondary calcite, which apparently has completely replaced the structure of the original shell material (pl. 31, fig. 56; pl. 30, fig. 26). The dorsal septum behaves optically as a single calcite crystal, the c-axis being parallel to the long axis of the septum. As a tentative explanation for the peculiar structure of the unexpanded septum under discussion, the writer suggests that perhaps the original septum, of the expanded type, was broken before burial of the valve, and that during the subsequent process of petrifaction the broken septum was extended anteriorly as a spike by the addition of calcite, the final form of the addition being at least partly controlled by the unicrystalline character of the base from which it grew. Thus the final form of the structure, although the result of both organic and inorganic processes, simulates a septum of purely organic origin.

The septum of *P. mimica* is interpreted by the writer as having a transverse expansion of its highest part, making the species congeneric with *P. trapeza*, although the possibility of two types of septa in otherwise identical valves must be considered; until a more thorough study of the species is made possible by the collection of more specimens, the problem cannot be finally settled.

Ventral valve: Posterior margin strongly indented at base of intertrough; profile subtriangular; pseudointerarea about 25° procline, straight or slightly concave; anterior slope concave near apex, convex or straight near margin; intertrough wider and deeper at commissure than at foramen, and characterized by medial well-defined, more or less depressed and flattened triangular granular area; foramen circular, about 0.03 mm. in diameter, situated slightly posterior to apex; fila flexed apically and enlarged by fusion along margins of posterior granular groove. Interior like that of *P. trapeza*, so far as can be determined.

Dorsal valve: Posterior margin slightly depressed at midpoint; apex marginal, with minute longitudinal groove or pit at summit, and projecting slightly beyond margin of ventral valve; umbo swollen, sharply raised above surfaces immediately lateral to it; anterior margin rectimarginate or very faintly sulcate; fila bent toward apex along median line, broken, and crinkled into a faint "criss-cross" pattern. Interior varies only in minor respects from that of *P. trapeza;* pseudointerarea typically somewhat narrower and more delicate than that of the genotype; median septum similar in all respects except that triangular plate and anteriorly projecting processes are developed horizontally and close to floor of valve instead of projecting sharply beyond plane of commissure; "cardinal" muscular scars clearly visible in most valves.

Dimensions (mm.) of Prototreta subcircularis

	Length	Width	Height	L/W	H/W
Ventral valve:					
Mont. T1187a	2.25	2.7	1.5	0.83	0.56
Dorsal valve:					
Mont. T1187b	2.5	2.8		0.89	

PROTOTRETA SUBCIRCULARIS Bell, n. sp.
Plate 31, figures 10–14

Outline subcircular or transversely ovate; ventral valve conical and of average height for the genus; dorsal valve nearly flat; fila faint and indefinite toward apex, stronger toward margin, blending laterally and longitudinally with adjoining fila; shell calcareocorneous, laminated, thinner than in *P. trapeza.*

Syntypes, Mont. T1187a–c.

Horizon and locality.—Middle Cambrian. Pentagon shale: 6-2, Pentagon Mt.; *26-4, Lick Creek.* Meagher limestone (*Bathyuriscus* zone): 45-3, 45-3a, M4-4, M4-4a, Nixon Gulch.

Distinguishing characters.—Prototreta subcircularis is characterized by its transversely subcircular outline, rectimarginate or very faintly sulcate anterior commissure, strongly procline ventral interarea, narrow dorsal

propareas, and nearly horizontal septal plate.

Discussion.—*Prototreta subcircularis* occurs in association with *P. trapeza* at two localities; although relatively rare at these places, it is abundant at Pentagon Mountain, where *P. trapeza* is absent. There appear to be no intermediate forms between the adult individuals of the two species, although in young specimens the dorsal valves are very similar.

PROTOTRETA TRAPEZA Bell
Plate 31, figures 34–48;
text figures 5–7

Protreta trapeza BELL, *1938*, Mich. Acad. Sci., Papers, vol. 23, p. 405, pl. 1, figs. 1–6.

Outline subtrapezoidal; ventral valve conical and of average height for the genus; dorsal valve moderately convex and sulcate; surface finely and closely filate, the fila blending laterally and longitudinally with adjoining fila; shell calcareocorneous, laminated.

Ventral valve: Posterior margin strongly indented at base of intertrough, anterior margin gently emarginate, posterolateral margins more sharply rounded then anterolateral margins; greatest width at point about one-third length from anterior margin; profile subtriangular; pseudointerarea catacline, distinctly concave; anterior slope more or less strongly convex; intertrough wider and deeper at commissure than at foramen, and characterized by medial well-defined, more or less depressed and flattened triangular granular area; foramen circular, about 0.03 mm. in diameter, situated slightly posterior to apex; fila flexed apically and enlarged by fusion along margins of posterior granular groove. Narrow internal ridge (pl. 31, figs. 39–40), with greatest height and breadth in middle third, extends from apex to center of posterior margin, where a slight projection fits into apical groove of dorsal valve; near its center, ridge bears a deep pit (pl. 31, fig. 38), evidently the internal opening of pedicle tube, which slants ventrally to external foramen (text fig. 6); crest of ridge traversed from pedicle opening to cardinal margin by shallow groove (pl. 31, figs. 39–40); small pit on either side of ridge and slightly dorsal to pedicle opening, probably seat of muscle attachment (pl. 31, fig. 38); two narrow, slightly diverging ribs extend anteriorly from pedicle opening, and disappear about halfway along anterior slope; strong groove (pallial sinus) borders each rib laterally and extends anteriorly from cardinal muscular pit to point near anterior margin of valve (pl. 31, figs. 39, 41). Inner ends of shell laminae in apical half of valve project inward, forming an incomplete "cone-in-cone" structure (pl. 31, fig. 41; text fig. 7); encircling shelf near apex partly separates a small chamber from main part of valve (pl. 31, fig. 39).

Dorsal valve: Posterolateral margins less strongly rounded than either anterolateral or posterior margins; posterior margin slightly depressed at midpoint; apex marginal, with minute longitudinal groove or pit at summit, and projecting slightly beyond margin of ventral valve; umbo swollen, sharply raised above surfaces lateral to it; posterior part of valve flat, becoming increasingly convex anteriorly; anterior margin straight or gently emarginate, broadly and strongly sulcate; width of sulcus at margin one-third that of shell, becoming narrow and shallow posteriorly, and disappearing before reaching apex; fila bent toward apex in bottom of sulcus, broken, and crinkled into a faint and imperfect criss-cross pattern. Propareas flat, about 45° anacline, raised above interior surface of valve on strong thickening of posterolateral margins, anterior edges project as a shelf; apical groove wide, shallow, traversed medially by a low, narrow ridge; sides of apical groove diverge anteriorly from apex at 90°; median septum (pl. 31, figs. 45–48) stout, expanding laterally in central third of valve into a broad, strong plate, which slopes ventrally beyond plane of commissure; plate apparently composed of five ribs, any or all of which may divide near anterior margin of plate and project as short, delicate fingerlike processes; two pairs of muscle scars positively identified (pl. 31, fig. 45); larger pair on posterior floor of valve, elongated anterolaterally almost in line with margins of apical groove; smaller pair at inner posterior margins of primary scars, adjoining posterior end of septum; third pair tentatively identified adjoining septum near its middle (pl. 31, fig. 45).

	Dimensions (mm.)				
	Length	Width	Height	L/W	H/W
Ventral valve:					
Mich. 20819a	2.5	2.9	1.8	0.86	0.62
Dorsal valves:					
Mont. 1535	2.7	3.1		0.87	
Mont. T1186b	3.2	3.6		0.89	

Holotype, Mont. 1535; paratypes, Mont. T1186a–c; Mich. 20819a–h; figured specimen, Mont. T1191a.

Horizon and locality.—Middle Cambrian. Meagher limestone (*Bathyuriscus* zone): *45-3*, *45-3a*, *M4-4*, *M4-4a*, U.S.N.M. loc. *19z*, *Nixon Gulch;* U.S.N.M. loc. 4o, head of Jackson Creek, Teton Mountains, Wyoming. Lower Meagher limestone: 47-3 loose, Beaver Creek. Pentagon shale: 26-4, 26-top (?), Lick Creek.

Distinguishing characters.—*Prototreta trapeza* is characterized by its subtrapezoidal outline, strong dorsal sulcus, catacline ventral pseudointerarea, and very sturdy dorsal septum.

Discussion.—No muscular impressions, other than the so-called cardinal muscular pits were observed in the ventral valve. The convexity of the dorsal valve apparently increases progressively with age. Considerable minor variation in the form of the dorsal septum occurs among associated individuals. The larger pair of muscular scars is visible in almost all dorsal valves, but the smaller pair was seen only in quite mature individuals. A few valves bore roughened callosities on the floor of the valve adjoining the septum opposite its point of lateral expansion; the callosities may represent points of muscular insertion. No evidence of pallial trunks has been observed in the dorsal valve.

Prototreta trapeza has furnished most of the information used in preparing the generic diagnosis. The reason for this is that the shells occur in a soft shale and can be readily cleaned with a needle to expose the important internal structures.

This species has been found in place at only two localities in Montana, where it occurs in similar calcareous shales. In the Teton Mountains of Wyoming it is present in a similar shale. These occurrences suggest that *P. trapeza* is limited to a distinct facies. A single dorsal valve showing the interior, and an associated fragment of a dorsal septum (pl. 31, figs. 36, 44) occur on a piece of limestone collected from talus at Beaver Creek. These specimens, which are referred to *P. trapeza*, are not quite typical of the species.

Genus HOMOTRETA Bell, n. gen.

(Gr. ὁμός, similar; τρητα, bored through)

Shell minute, calcareocorneous, laminated; outline subcircular or transversely subelliptical. Ventral valve like that of *Prototreta*, except that internal "cone-in-cone" structure is not so strongly developed. Dorsal valve like that of *Prototreta*, except that the median septum is high and bladelike, without lateral expansion.

Genotype, *Homotreta interrupta* Bell, n. sp.

Distinguishing characters.—*Homotreta* is characterized by a conical ventral valve with foramen posterior to apex, and internal "cone-in-cone" structure; dorsal valve with flattened propareas bounding a triangular muscular (?) pit, and a high bladelike median septum.

Discussion.—*Homotreta* apparently differs from *Prototreta* only in having a keellike median septum, the crest sloping gently posteriorly and anteriorly from its highest point. Only one species is known from Montana (*H. interrupta*). It appears that *Acrotreta marjumensis* Walcott=*Acrotreta ophirensis descendens* Walcott belongs to this genus. Probably other species from the Cordilleran province, now assigned to *Acrotreta*, will prove to be congeneric with *Homotreta interrupta* when their internal morphology is made known.

Homotreta differs from *Pegmatreta*, with which it is associated in the "Pagoda" limestone on Lick Creek (localities 26-2, 26-3), in possessing "cone-in-cone" structure of the ventral valve, distinct dorsal propareas and high dorsal septum, and in lacking an internally thickened ventral apex.

HOMOTRETA INTERRUPTA Bell, n. sp.

Plate 30, figures 19–26; text figures 1–4

Outline subcircular or transversely sub-

elliptical; ventral valve conical, dorsal valve slightly convex; fila strongly defined, regularly spaced, slightly crenulated and irregularly segmented on marginal third of valve; distance between crests of ridges about 0.03 mm. on a shell 4 mm. in width; average length of segments about 0.1 mm.; gaps between segments of same ridge about 0.03 mm.; shell calcareocorneous, laminated.

Ventral valve: Posterior margin flattened for a distance that may equal half width of valve, and slightly incurved at base of intertrough; profile triangular; pseudointerarea 20°–25° procline, and straight from apex to margin; anterior slope about twice length of posterior slope and slightly convex, except immediately anterior to apex, where it becomes concave; intertrough wider and deeper at commissure than at apex, and characterized by medial, more or less depressed and flattened granular area; foramen circular, 0.03 mm. in diameter, situated slightly posterior to apex. Interior like that of *Prototreta flabellata*, so far as can be determined.

Dorsal valve: Profile slightly convex, greatest convexity being near middle of valve; posterior margin slightly depressed at midpoint; apex minute, marginal, knoblike, with pit or longitudinal groove at summit; anterior margin gently sulcate; sulcus becoming narrow and shallow posteriorly, disappearing on elevated umbo; fila bent abruptly posteriorly along median line of sulcus, where they break and develop a distinct criss-cross pattern (pl. 30, fig. 22). Pseudointerarea (muscular pit and propareas) like that in *Prototreta subcircularis;* median septum a narrow bladelike structure, the crest of which rises slowly to its highest point in anterior third of valve, and thence slopes abruptly to the anterior margin (text fig. 2).

Dimensions (mm.)

	Length	Width	Height	L/W	H/W
Ventral valve:					
Mont. T1194b	2.9	3.7	1.4	0.78	0.38
Dorsal valve:					
Mont. T1194c	2.7	2.9		0.93	

Syntypes, Mont. T1194a–h.

Horizon and locality.—Middle Cambrian. "Pagoda" limestone: *26-2, 26-3, Lick Creek;* 28-1, Rock-Baldy Bear Creek ridge.

Discussion.—As, unfortunately, it has proved impossible to excavate the interior of the ventral valve, all information has been obtained from serial sections and one imperfect internal mold. So far as can be ascertained, the ventral internal structure is quite similar to that of *Prototreta trapeza*, the shell being somewhat thinner. The cardinal muscular pits, the two diverging pallial trunks, and the callosity behind the intertrough have been observed. Cross-sections clearly show the internal ends of the shell laminae extending into the apical cavity (text figs. 3–4).

Homotreta interrupta is a homoeomorph of *Prototreta flabellata*, differing from it only in internal characters. This relationship has been discussed in the section on Homoeomorphy.

Genus PEGMATRETA Bell, n. gen.

(Gr. πῆγμα, thickened; τρῆτα, bored through)

Outline subcircular or transversely subelliptical; ventral valve obliquely conical, or strongly convex with incurved apex; dorsal valve slightly or moderately convex; surface finely filate; shell calcareocorneous, laminated.

Ventral valve: Intertrough moderately developed; foramen circular, posterior to apex. Apex strongly thickened internally by a subconical callosity with deeply excavated posterior slope, forming a deep pit, into which the pedicle tube opens; shell laminae do not project into the interior.

Dorsal valve: Umbo swollen; beak strongly incurved; apex without pit or groove at summit. Triangular muscular pit present at apex; posterolateral margins of valve hardly thickened, propareas barely perceptible; septum a long, low, narrow, rounded ridge.

Genotype, *Pegmatreta perplexa* Bell, n. sp.

Distinguishing characters.—*Pegmatreta* is characterized by the strong internal thickening of the ventral apex, pedicle foramen posterior to apex, obsolete dorsal propareas, and low median ridge in the dorsal valve.

Discussion.—Several described species,

now assigned to *Acrotreta*, may belong to *Pegmatreta*, but an investigation of them is beyond the scope of this paper. It should be pointed out that *Acrotreta ophirensis* Walcott and *A. idahoensis* Walcott have strongly thickened ventral apices, and foramina posterior to the apex. Both species have much thicker shells than have *Pegmatreta rotunda* and *P. perplexa*, which may account for the apparent internal differences in the dorsal valves.

Pegmatreta perplexa and *P. rotunda*, described in this paper, are strikingly different in the form of their ventral valves, but are placed in the same genus because of internal similarities. Possibly the characters regarded here as generic may prove to be of family rank, but further investigation is necessary to answer this question.

PEGMATRETA PERPLEXA Bell, n. sp.
Plate 30, figures 11–14;
text figure 11

Outline subcircular to transversely subelliptical; ventral valve obliquely subconical, dorsal valve slightly convex; fila distinct, threadlike, often segmented. Shell calcareocorneous, laminated.

Ventral valve: Posterior margin slightly indented at base of intertrough; profile obtusely subtriangular; pseudointerarea about 45° procline and straight from apex to margin, anterior slope slightly and regularly concave; intertrough shallow, characterized by flattened and granular center; foramen circular, 0.03 mm. in diameter, opening backward through slight subquadrate callosity on posterior side of truncated apex. Apex strongly thickened internally into a subconical callosity; margin of callosity extended a short distance anteriorly as a ridge; posterior slope of callosity excavated by a deep pit, into floor of which opens the pedicle foramen; pair of depressions on anterolateral slopes of callosity may be muscular scars.

Dorsal valve: Profile gently convex; umbo swollen; beak incurved; apex without pit or groove at summit; anterior margin usually faintly sulcate; sulcus most distinct on anterior slope of umbo. Propareas indistinct, bordering a wide shallow pit, probably for muscular attachment; septum long, low, narrow.

Dimensions (mm.)

	Length	Width	Height	L/W	H/W
Ventral valve:					
Mich. 20810a	2.1	2.55	0.5?	0.82	0.2
Dorsal valve:					
Mich. 20810b	1.75	2.00		0.87	

Syntypes, Mich. 20810a–c.

Horizon and locality.—Middle Cambrian. Meagher limestone (*Bathyuriscus* zone): *45-3*, 45-3a, *M4-4*, M4-4a, *Nixon Gulch*. Lower Meagher limestone: 47-3, Beaver Creek. "Pagoda" limestone: 26-2, 26-3, Lick Creek. Pentagon shale: 6-2, Pentagon Mountain; 26-4, Lick Creek.

Distinguishing characters.—*Pegmatreta perplexa* is characterized by its obtusely conical ventral valve with a circular foramen opening from a subquadrate callosity posterior to apex.

Discussion.—The presence of *Pegmatreta perplexa* in both the "Pagoda" limestone and Pentagon shale is unexpected; so far as can be determined, the "Pagoda" specimens differ from those in the Pentagon only in being uniformly somewhat larger and in having a slightly more rounded ventral apex. Inasmuch as the preservation of the specimens in the fine-grained calcareous shales of these formations is not sufficiently good to ascertain whether slight specific differences exist, it seems best at present to assign the "Pagoda" and Pentagon forms to the same species.

Pegmatreta perplexa is readily distinguished from all other species in Montana, as well as from all described species now assigned to *Acrotreta*, by its very obtusely conical and low ventral valve, with a circular foramen posterior to the apex.

PEGMATRETA ROTUNDA Bell, n. sp.
Plate 30, figures 27–31;
text figure 17

Outline subcircular to transversely subelliptical; ventral valve strongly convex, with beak incurved over posterior margin; dorsal

valve slightly convex; surface fila fine, continuous, tending to crinkle near anterior margin of shell; shell calcareocorneous, laminated.

Ventral valve: Posterior margin slightly indented at base of intertrough; profile strongly convex, highest point being in posterior third of valve; pseudointerarea catacline; intertrough present, narrow; beak incurved and crushed in all available specimens; foramen unknown, but probably posterior to apex. Interior like that of *P. perplexa*, so far as observed, with subconical callosity projecting inward and bounding a deep pit posterior to it; shell laminae do not project into interior of valve (text fig. 17).

Dorsal valve: Profile moderately convex, with swollen umbo and incurved beak; apex without pit or groove at summit. Interior like that of *P. perplexa;* propareas obsolete; shallow triangular depression at apex, probably for muscular attachment; septum long, low, slightly wider anteriorly.

which event the two species may prove to be congeneric.

P. rotunda is known from only one locality, and all the specimens available for study are more or less crushed and broken. The matrix, a fine-grained, hard, shaly limestone, is difficult to remove with a needle, and consequently preparation by this method yielded meager results. The information regarding the thickened ventral apex came from thin sections (text fig. 17).

Genus CERATRETA Bell, n. gen.

(Gr. κέρας, horn; τρῆτα, bored through)

The genus *Ceratreta* is proposed to include a single species of Upper Cambrian acrotretids, characterized by a bluntly subconical ventral valve with deep intertrough and foramen posterior to apex, and a dorsal valve with an internal median septum, which is projected into a stout vertical hornlike process near its anterior end. The shell is calcareocorneous and laminated.

Dimensions (mm.)

	Length	Width	Height	L/W	H/W
Ventral valve:					
Mont. T1195a	4.0?	4.4?	0.83	0.91	0.19
Dorsal valves:					
Mont. T1195b	3.2	3.3?		0.97	
Mont. T1195c	4.2	4.5		0.93	

Syntypes, Mont. T1195a–e.

Horizon and locality.—Middle Cambrian. "Pagoda" limestone: 26-2, 26 3, Lick Creek.

Distinguishing characters.—*Pegmatreta rotunda* is characterized by its strongly convex ventral valve, with apex incurved over catacline pseudointerarea.

Discussion.—*Pegmatreta rotunda* is readily distinguished from any other species in Montana by the form of its ventral valve, but it is strikingly similar to *Acrotreta ophirensis* Walcott from the Middle Cambrian of the Oquirrh (Ophir formation) and House (Marjum formation) Ranges, Utah. The latter species, in addition to having a much more convex dorsal valve, differs from *Pegmatreta rotunda* in possessing structures and markings, in addition to the median septum, on the floor of the dorsal valve. These structures and markings may be present only because *Acrotreta ophirensis* has a much thicker shell than *Pegmatreta rotunda*, in

Genotype, *Ceratreta hebes* Bell, n. sp.

Discussion.—The single species of this genus is known from only three localities, and the specimens are neither abundant nor well preserved. In the writer's opinion the hornlike projection of the dorsal septum is the most striking generic character. This type of septum has not previously been described, but is present in *Acrotreta microscopica* (Shumard). (See discussion of *"Acrotreta" tetonensis*.)

CERATRETA HEBES Bell, n. sp.

Plate 29, figures 10–17

Outline subcircular or transversely subelliptical; ventral valve bluntly conical; dorsal valve moderately convex; surface distinctly and finely filate; shell calcareocorneous, laminated.

Ventral valve: Profile subsemielliptical, highest point being anterior to apex; pseudointerarea about 30° procline and straight from apex to margin; anterior slope strongly

convex; intertrough present on apical half of posterior slope, narrow, deep; marginal half of posterior slope slightly flattened; foramen circular, minute, situated at upper end of intertrough just below incurved apex; apex rounded, somewhat knoblike. Interior with high median ridge on posterior slope; pedicle tube slants dorsally from foramen through ridge toward interior of valve (pl. 29, fig. 16).

Dorsal valve: Profile moderately convex, highest point at middle of valve; beak strongly incurved over posterior margin; apex blunt, without pit or groove at summit. Interior with subtriangular concave shelf at apex, presumably for muscular attachment, somewhat excavated below on either side of median septum; septum stout, rounded in cross section, originating below level of apical shelf, and projecting into a high hornlike process in anterior third of valve; slight depression present on crest of septum at its posterior end.

Dimensions (mm.) of Ceratreta hebes

	Length	Width	Height	L/W	H/W
Ventral valve:					
Mont. T1197b	1.25?	1.75?	0.88?	0.71	0.5
Dorsal valve:					
Mont. T1197a	1.5?	1.9?		0.79	

Syntypes, Mont. T1197a–f.

Horizon and locality.—Upper Cambrian. Dry Creek shale: *46-3, Nixon Gulch.* Snowy range formation: M1-4, Beartooth Butte; M2-1, Cooke.

Distinguishing characters.—Ceratreta hebes is characterized by its bluntly conical ventral valve, with deep intertrough and foramen posterior to apex, concave shelf at apex of dorsal valve, and median dorsal septum projected into a high hornlike process.

Discussion.—Ceretreta hebes is distinguished from all other brachiopods known to the writer by the form of its ventral valve.

The ventral interior of this species is not well known, but a fractured valve (pl. 29, fig. 16) shows clearly the nearly vertical pedicle tube contained within the high ridge on the inner side of the posterior slope. (See *"Acrotreta" tetonensis* for a discussion of the apparent relationship of *Ceratreta hebes* to *Acrotreta microscopica.*)

"Acrotreta" tetonensis Walcott

Plate 31, figures 1–9

Acrotreta microscopica tetonensis Walcott, *1902*, U. S. Nat. Mus., Proc., vol. 25, p. 590; *1912*, U. S. Geol. Survey, Mon. 51, p. 694, pl. 67, figs. 3, 3a–d.

Outline subcircular; ventral valve obliquely and sharply subconical; dorsal valve slightly convex; fila fine, sharp, continuous; shell calcareocorneous, laminated.

Ventral valve: Posterior margin nearly straight; profile obliquely subtrigonal; pseudointerarea slightly curved, about 80° apsacline; anterior slope moderately convex; apex sharply pointed, perforated by a circular foramen, and extending beyond posterior margin; pseudointerarea distinctly flattened to slightly concave, crossed smoothly by fila, which flex gently toward apex; intertrough absent. Interior with strong cardinal muscular pits near posterolateral margins of valve; pedicle tube opens internally into a central chamber, which is separated from two lateral chambers of the valve by a pair of strong septa; central chamber occupies probably apical third to half of valve; septa fuse near middle of anterior slope and form a broad low elevation (pl. 31, fig. 3).

Dorsal valve: Profile moderately convex; central posterior margin slightly depressed; apex knoblike, elevated above surface of valve lateral to it, and carrying median groove at summit. Interior with moderately developed propareas bounding central subtriangular depression; broad, low callosity anterior to apical depression continued (?) anteriorly as a low narrow septum; broad cardinal muscular scars present on posterolateral margins of valve floor, adjoining inner margins of propareas.

Dimensions (mm.) of "Acrotreta" tetonensis

	Length	Width	Height	L/W	H/W
Ventral valve:					
Mont. T1199b	1.25?	1.4?	0.75?	0.89	0.54
Dorsal valve:					
Mont. T1199e	1.5?	1.5?		1.00	

Hypotypes, Mont. T1199a–g.

Horizon and locality.—Upper Cambrian. Dry Creek shale: 44-2, Crowfoot Ridge; 46-3, Nixon Gulch; U.S.N.M. localities *4e, head of Jackson Creek, Teton Mountains, Wyoming;* 302w, Madison Mt. Snowy Range formation: M1-4, Beartooth Butte.

Discussion.—Unfortunately, only a few fragmental dorsal valves are present in the writer's collections of "*A.*" *tetonensis*, and they yield discouragingly little information. The dorsal valves among the types of "*A*," *tetonensis* are all exteriors, and there is no surplus material that can be prepared to reveal the interior. "*A.*" *tetonensis* and *Acrotreta microscopica* (Shumard) are very similar, apparently differing only in the form of the ventral valve. Investigation of a dorsal valve of *A. microscopica* from U.S.N.M. loc. 67, Burnet County, Texas, revealed an internal septum projected into a high horn-like elevation, like that in *Ceratreta hebes*. Unfortunately, the problem could not be investigated further. If all the dorsal valves have been correctly assigned, there is a close, at least family, relationship between *Ceratreta hebes* on the one hand, and "*Acrotreta*" *tetonensis* and *Acrotreta microscopica* on the other.

Genus LINNARSSONELLA Walcott, 1902

LINNARSSONELLA ELONGATA Bell, n. sp.

Plate 31, figures 15–19; text figures 8–10

Outline elongate subtrigonal, greatest width anterior to middle; anterior margin broadly rounded, posterior margin more sharply rounded; profile unequally biconvex, convexity of ventral valve being the greater; surface very glossy, with subdued growth lines; shell calcareocorneous, laminated, greatly thickened in umbonal region.

Ventral valve: Profile strongly convex, greatest convexity in posterior third of valve; beak bluntly pointed, incurved; pseudointerarea about 60° apsacline, not flattened, characterized by increased rugosity and very close grouping of growth ridges; foramen minute, circular, situated immediately posterior to apex. Middle of posterior commissure slightly convex dorsally, the projection fitting into apical depression of dorsal valve; posterolateral margins narrow and slightly projected dorsally as "teeth," which fit into deep furrows in dorsal valve; foramen opens internally into narrow, deep furrow, which widens slightly anteriorly and disappears about one-third length of valve from apex; cardinal muscular pits deep, situated in posterolateral slopes about opposite "teeth"; pallial trunks straight, shallow, divergent, originating adjacent to median furrow near apex.

Dorsal valve: Shorter and less acuminate posteriorly than ventral valve; profile moderately convex, greatest convexity in posterior third of valve; beak incurved; apex marginal, formed by a pair of minute projections. Posterior portion of valve strongly thickened internally into a broad and long platform with concave upper surface, presumably for muscular insertion and reception of projecting margin of ventral valve; posterolateral margins thickened, bearing deep furrows for reception of "teeth" of ventral valve; short, stout median septum or ridge originates at anterior margin of apical platform and extends to middle of valve; crest of ridge broadened and flattened at its posterior end; pair of deep cardinal muscular pits present, excavated in thickened posterolateral slopes of valve.

Dimensions (mm.)

	Length	Width	L/W
Ventral valve:			
Mich. 20811e.....	2.33	2.0	1.16
Dorsal valve:			
Mich. 20811d.....	2.17	2.0	1.08

Syntypes, Mich. 20811a–e.

Horizon and locality.—Upper Cambrian. Dry Creek shale: 44-2, Crowfoot Ridge. Snowy Range formation: *M1-4, Beartooth Butte.*

Distinguishing characters.—*Linnarssonella elongata* is characterized by its elongate subtrigonal outline, strong biconvexity, bluntly rounded ventral apex, and slightly apsacline, unflattened ventral pseudointerarea.

Discussion.—*Linnarssonella elongata* differs from *L. girtyi* Walcott, the only described species of *Linnarssonella* of which the type or topotype specimens are well enough preserved for comparison, in having an elongate subtrigonal outline, a more bluntly rounded ventral apex, and an unflattened ventral pseudointerarea.

Genus NISUSIA Walcott, 1905

The studies by Schuchert and Cooper (1932, p. 44) and Cooper (1936, p. 212) have established the generic characters of *Nisusia* quite completely. No additional information concerning the internal structure of the genus resulted from the present study.

Among the species of *Nisusia* represented in the United States National Museum by ventral valves sufficiently well preserved to show the original convexity, *N. lowi* (Walcott) and *N. spencei*[7] (Walcott) are unique in that the highest part of the valve is toward the middle, the apex being incurved over a moderately apsacline interarea. In contrast, *N. alberta* (Walcott), *N. amii* (Walcott), *N. burgessensis* Walcott, *N. borealis* Cooper, *N. erecta* (Walcott), *N. festinata* (Billings) (genotype), and *N. utahensis* (Walcott) are characterized by a ventral valve in which the apex is the highest point, the interarea being strongly apsacline to catacline. *Nisusia deissi* and *N. montanaensis* described in this paper belong to the former group, whereas *N. lickensis* and *N.* sp. 1 belong to the latter. None of the four species belonging to the evenly convex group possess spinose costellae, but many, if not most of the uptilted-apex type do possess spines. It may be that these differences are of generic rank, but more information is needed before the question can be decided.

[7] Resser's (1939a, p. 6) assignment of *Nisusia spencei* (Walcott) and *N. rara* Walcott to the genus *Wimanella* is without foundation.

NISUSIA DEISSI Bell, n. sp.
Plate 32, figures 1–6

Nisusia sp. COOPER, *1936*, Jour. Paleontology, vol. 10, no. 3, pl. 26, figs. 27, 29.

Outline transversely rounded subrectangular; lateral margins smoothly and gently convex outward; hinge less than width of valve at middle; cardinal extremities obtusely angular, slightly mucronate in immature individuals; anterior commissure emarginate; sulcus present in both valves, somewhat narrower and deeper in ventral valve; profile strongly and evenly biconvex, the convexity of the dorsal valve being slightly the greater; both beaks incurved, the dorsal more so than the ventral; ventral interarea longer than dorsal; surface evenly paucicostellate, costellae strong, rounded, beaded near margin by junction with rugose growth lamellae; intercostellate areas flat, twice width of costellae, crossed only by fila and strong growth ridges.

Ventral valve: Posterior margins slightly concave; apex pointed, apical angle about 140°; sulcus a gentle flexure of shell, faint at apex, deeper and wider at margin; convexity greatest slightly anterior to middle of shell; interarea concave, about 30° apsacline; delthyrium wide, apical third covered by short, thick, very convex deltidium; delthyrial angle about 90°; apical foramen small, circular, evidently shared both by deltidium and apex of valve. Interior paucicostellate, without muscular and pallial markings in all specimens observed.

EXPLANATION OF PLATE 32

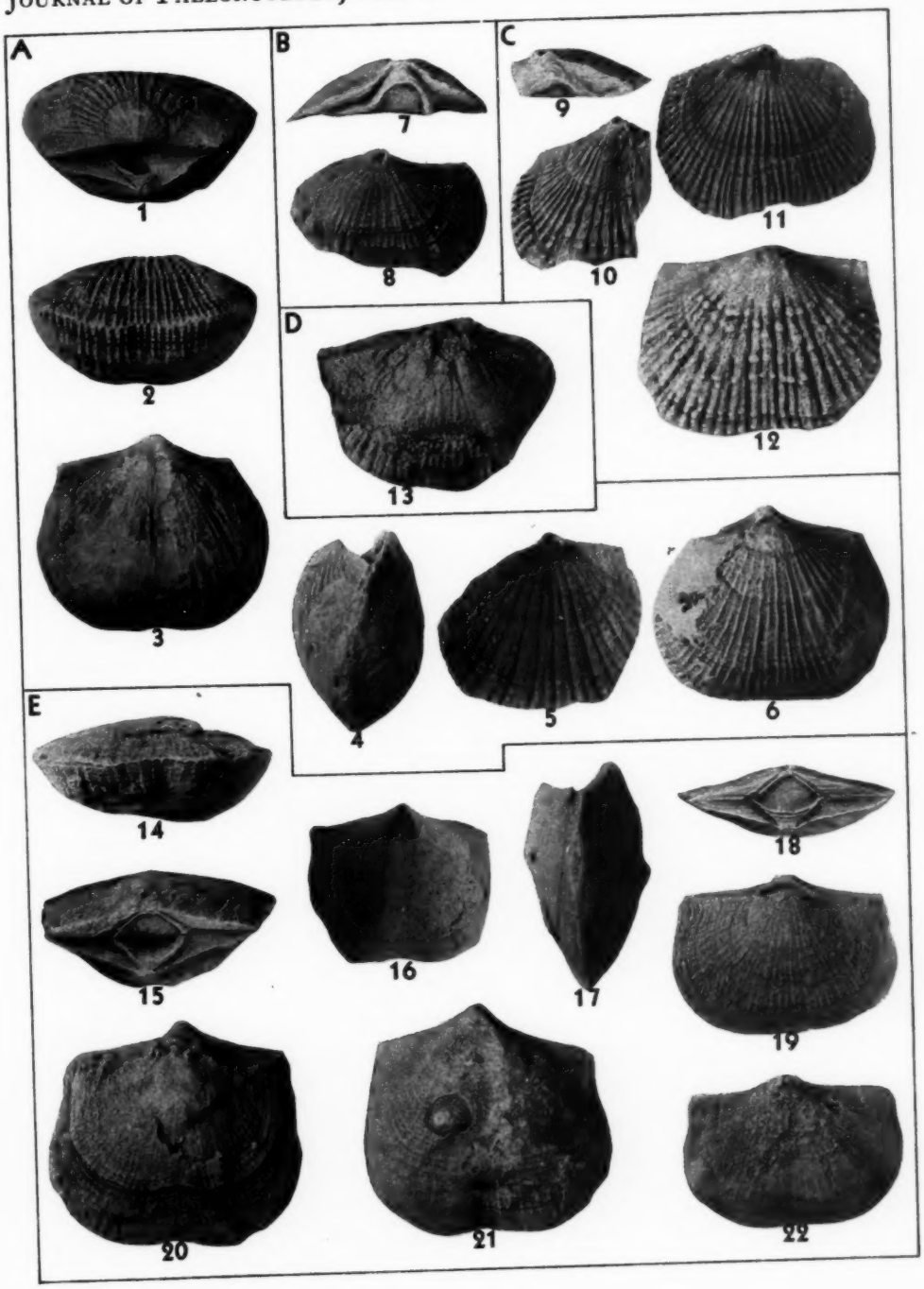
FIGS. *1–6*—*Nisusia deissi* Bell, n. sp. *1–4, 6*, Holotype; posterior, anterior ventral, lateral, and dorsal views of a complete specimen, Mich. 20803a, ×2, loc. M3-1. *5*, Paratype; interior of incomplete ventral valve, showing costellation, Mich. 20803b, ×3, loc. M3-1. Middle Cambrian: Meagher limestone. (p. 236)

7–8—*Nisusia* sp. 1. Figured specimen; posterior and surface views of incomplete ventral valve, Mont. T1176a, ×3, loc. 20-2. Middle Cambrian: Damnation limestone. (p. 239)

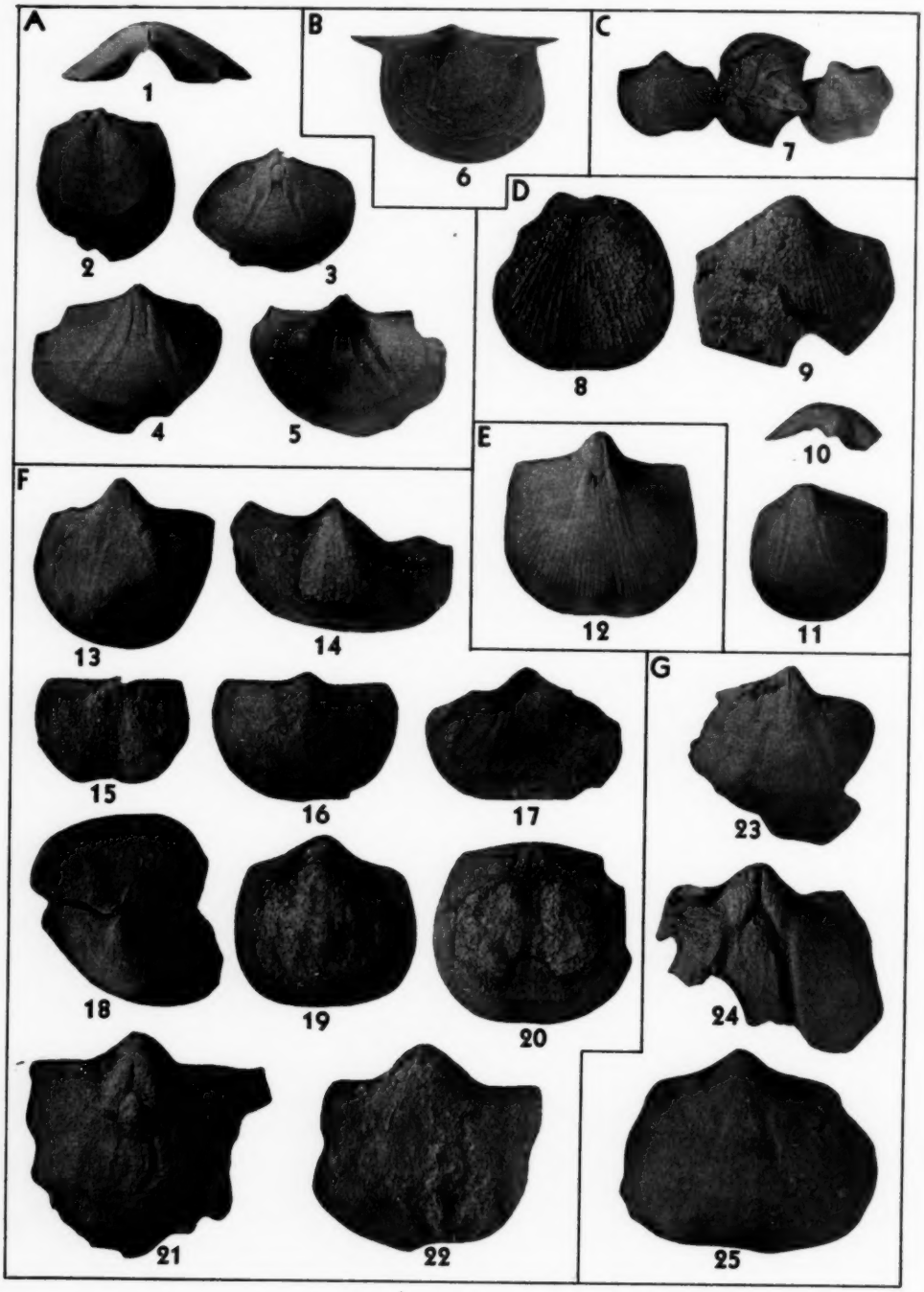
9–12—*Nisusia lickensis* Bell, n. sp. *9, 10*, Syntype; posterior and surface views of incomplete ventral valve, Mont. T1178a, ×3, loc. 26-loose. *11*, Syntype; interior of incomplete ventral valve, showing short adductor track and linear diductor tracks, Mont. T1178c, ×3, loc. 26-top. *12*, Syntype; exterior of dorsal valve, showing stout nodes or spine bases on costellae Mont. T1178b, ×3, loc. 26-loose. Middle Cambrian: Pentagon shale. (p. 238)

13—*Nisusia*, sp. 2. Figured specimen; badly weathered internal mold showing suggestion of notothyrial platform, Mont. T1179a, ×2, loc. 20-2. Middle Cambrian: Damnation limestone. (p. 239)

14–22—*Nisusia montanaensis* Bell, n. sp. *14, 15, 17, 20, 21*, Holotype; anterior, posterior, lateral, dorsal, and ventral views of a complete mature specimen, Mich. 20804a, ×2, loc. M3-1. *16*, Paratype; interior of incomplete ventral valve, showing absence of costellae and muscular impressions, Mich. 20804c, ×2, loc. M3-1. *18, 19, 22*, Paratype; posterior, dorsal, and ventral views of a complete immature specimen, Mich. 20804b, ×2, loc. M3-1. Middle Cambrian: Meagher limestone (p. 236)



Bell, Cambrian Brachiopoda



Bell, Cambrian Brachiopoda

Dorsal valve: Outline transversely subquadrate, or subelliptical except for obtusely angular or slightly mucronate cardinal extremities; hinge considerably less than width of valve at middle; posterior margins concave; apex bluntly rounded, apical angle about 160°; sulcus broad, shallow, not apparent in posterior third of valve; interarea short, flat, about 60° anacline; notothyrium wide, open so far as observed; notothyrial angle about 100°. Interior paucicostellate, without muscular and pallial markings in all specimens observed.

Dimensions (mm.)

	Length	Width	Hinge width	L/W
Ventral valve:				
Mich. 20803a....	14.5	17.0	13.5	0.85
Dorsal valve:				
Mich. 20803a....	13.3	17.0	13.5	0.78

Holotype, Mich. 20803a; paratype, Mich. 20803b.

EXPLANATION OF PLATE 33

FIGS. *1–5—Wimanella rossensis* Resser. *1, 4*, Hypotype; posterior and surface views of ventral internal mold, showing broad compound pallial trunks, restricted adductor impression, apical septum, and inflected posterior margin of delthyrial cavity, U.S.N.M. 97072, ×3, loc. 63m′. *5*, Hypotype; clay squeeze from same mold, U.S.N.M. 97072, ×3, loc. 63m′. *2*, Syntype (Walcott, 1917a, pl. 4, fig. 8a, as ventral valve); surface view of dorsal internal mold, showing impressions of brachiophores, U.S.N.M. 63717, ×2, loc. 63m′. *3*, Syntype (Walcott, 1917a, pl. 4, fig. 8); surface view of ventral internal mold, U.S.N.M. 63716, ×2, loc. 63m′. Middle Cambrian: Ross Lake shale member of Cathedral dolomite, south slope of Mt. Bosworth, British Columbia. (p. 241)

6—Wimanella aurialis Bell, n. sp. Holotype; impression of exterior of ventral valve, Mont. T1192a, ×3, loc. 40-2. Middle Cambrian: Wolsey shale. (p. 241)

7—Diraphora bellicostata (Walcott). Hypotypes; three ventral valves, including one exterior and two partial internal molds. The center valve shows clearly the strong pallial trunks and narrow diductor tracks apparently continuous with them, U.S.N.M. 97077, ×1.5, loc. 35k. Middle Cambrian: Burgess shale, above Field, British Columbia (p. 243)

8–11—Diraphora striata (Walcott), *8*, Paratype (Mon. 51, pl. 86, fig. 4c); exterior of incomplete and poorly preserved dorsal valve, presumably belonging to this species, U.S.N.M. 52279d, ×3, loc. 149a. *9*, Holotype (Mon. 51, pl. 86, fig. 4); exterior of incomplete ventral valve, U.S.N.M. 52279a, ×3, loc. 149a. *10, 11*, Hypotype; posterior and surface views of ventral internal mold, showing compound pallial trunks and narrow diductor tracks apparently continuous with them, U.S.N.M. 52279e, ×2, loc. 149a. Middle Cambrian: Meagher limestone. (p. 243)

12—Diraphora? sp. Figured specimen; surface view of ventral internal mold. Mont. T1183a, ×3, loc. 47-2. Middle Cambrian: Meagher limestone. (p. 244)

13–22—Wimanella simplex Walcott. *13*, Hypotype; surface view of ventral internal mold, showing widely divergent pallial trunks, and radial striae near anterior margin of mold, Mont. T1184a, ×3, loc. 23-1. *14*, Hypotype; internal mold of delthyrial cavity, showing narrow diductor tracks, U.S.N.M. 52277e, ×3, loc. 4w. *15*, Hypotype; surface view of dorsal internal mold, U.S.N.M. 97073d, ×3, loc. 4v. *16*, Holotype (Mon. 51, pl. 89, fig. 2); exterior of crushed and poorly preserved ventral valve, U.S.N.M. 52278a, ×3, loc. 4v. *17*, Hypotype; interior of incomplete ventral valve, showing widely divergent pallial trunks, U.S.N.M. 52278c, ×2, loc. 4v. *18*, Paratypes (Mon. 51, pl. 89, fig. 2e); exteriors of associated dorsal and ventral valves, U.S.N.M. 52278b, ×3, loc. 4v. *19*, Hypotype; surface view of ventral internal mold, showing procline interarea and deep delthyrial cavity, U.S.N.M. 97073b, ×3, loc. 4v. *20*, Hypotype; surface view of dorsal internal mold, showing anacline interarea, broad notothyrial ridge that may be a rudimentary cardinal process, and faint radial striae near anterior margin of mold, U.S.N.M. 97073a, ca. ×2, loc. 4v. *21*, Hypotype (Mon. 51, pl. 89, fig. 2d); surface view of ventral internal mold, showing abnormal development of diductor tracks and adductor impression, U.S.N.M. 52277d, ×2, loc. 4w. *22*, Hypotype; surface view of ventral internal mold, showing faintly the radial striae in marginal portion of valve, U.S.N.M. 52277f, ×3, loc. 4w. Middle Cambrian: Gordon shale. (p. 242)

23–25—Wimanella highlandensis (Walcott). *24*, Holotype (Mon. 51, pl. 87, fig. 4b); surface view of incomplete ventral internal mold, showing abnormal development of diductor scars and the ridge or septum between them, U.S.N.M. 15355c, ×3, loc. 31a. *23*, Paratype (Mon. 51, pl. 87, fig. 4a), and *25*, hypotype; surface views of ventral internal molds showing what is thought to be a more normal development of the adductor impression, diductor tracks, apical septum, and pallial trunks, U.S.N.M. 15355b (×2), 15355e (×1.5), loc. 31a. Middle Cambrian: probably Comet shale (Deiss, 1938, p. 1160), near Pioche, Lincoln County, Nevada. (p. 241)

Horizon and locality.—Middle Cambrian. Meagher limestone (*Ehmania* zone): *M3–1*, U.S.N.M. loc. *20k*, *Pole Creek;* 43-3, Crowfoot Ridge; U.S.N.M. 5k (1) (?), head of Sawmill Creek. Limestone in upper Wolsey shale: 31-1 (?), Hoover Creek; 34-5 (?), South Hill; U.S.N.M. loc. 5f (?), head of Sawmill Creek. "Pagoda" limestone: 28-1, Rock-Baldy Bear Creek ridge.

Distinguishing characters.—Nisusia deissi is characterized by its strong biconvexity, very short and convex deltidium, small circular apical foramen, and strong rounded costellae with wide flat interspaces. There appears to be no described species of *Nisusia* with which *N. deissi* might be confused.

NISUSIA LICKENSIS Bell, n. sp.
Plate 32, figures 9–12

Outline transversely subrectangular; hinge less than width of valve at middle; cardinal extremities obtusely rounded or angular; anterior commissure emarginate; profile moderately and asymmetrically biconvex, ventral valve being highest at apex; ventral interarea much longer than dorsal; surface coarsely and evenly fascicostellate, the costellae bearing nodes or spine bases; growth lamellae rarely present.

Ventral valve: Posterior margins evenly concave; apex pointed; apical angle about 135°; anterior slope convex marginally and concave near beak, making apex highest point of valve; sulcus narrow, shallow, most prominent in middle portion of valve; interarea strongly apsacline; deltidium convex, covering about half of delthyrium, its lower margin concave; foramen prominent, shared by apex and deltidium. Interior coarsely fascicostellate; adductor track short, broad; diductor scars linear, projecting anteriorly beyond adductors.

Dorsal valve: Posterior margins faintly concave; apex broadly rounded; apical angle about 160°–165°; umbo slightly swollen, posterolateral flanks flattened to concave; sulcus shallow, broad: profile evenly convex, highest near middle. Interior fascicostellate.

Dimensions (mm.)

	Length	Width	Hinge width	L/W
Dorsal valve:				
Mont. T1178b...	8.8	11.8	10.5?	0.74

Syntypes, Mont. T1178a–c.

Horizon and locality.—Middle Cambrian. Pentagon shale: 26-top, 26-loose, Lick Creek.

Discussion.—Nisusia lickensis appears most closely related to *N. alberta* Walcott and *N. borealis* Cooper. It differs from the former in being smaller and considerably less transverse, and in having obtuse or rounded instead of acutely angular cardinal extremities. From the latter it differs in having a more evenly convex and swollen dorsal valve, and in possessing spines which are stouter and relatively farther apart on the costellae.

NISUSIA MONTANAENSIS Bell, n. sp.
Plate 32, figures 14–22

Outline transversely subrectangular in immature individuals, approaching subquadrate in mature shells; lateral margins subparallel; hinge slightly less than width of shell at middle; cardinal extremities mucronate in young specimens, becoming obtusely angular in mature shells; anterior commissure slightly emarginate; sulcus present in both valves, ventral sulcus being the deeper; profile moderately and subequally biconvex, greatest height in posterior third of shell; ventral beak incurved, projecting slightly beyond that of dorsal; ventral interarea slightly longer than dorsal; surface subdued paucicostellate; costellae low, rounded, scarcely affected by numerous fila and growth lamellae.

Ventral valve: Posterior margins straight, becoming concave near beak, which is obtusely pointed; apical angle of a large valve about 135°; interarea concave, about 45° apsacline; delthyrium wide, apical third or less covered by moderately convex deltidium; delthyrial angle about 90°; apical foramen minute, and sealed in most specimens. Interior smooth, so far as known, without pallial and muscular marks.

Dorsal valve: Outline transversely subrectangular to subquadrate; lateral margins subparallel; posterior margins straight; apical angle nearly 180°; interarea flat, strongly anacline; notothyrium wide; notothyrial angle about 100°; small chilidium present. Interior smooth, so far as known, without pallial and muscular marks.

Dimensions (mm.)

	Length	Width	Hinge width	L/W
Ventral valves:				
Mich. 20804a....	16.2	18.1	15.3	0.90
Mich. 20804b....	11.6	16.4	14.5	0.71
Dorsal valves:				
Mich. 20804a....	15.0	18.1	15.3	0.83
Mich. 20804b....	10.6	16.4	14.3	0.65

Holotype, Mich. 20804a; paratypes, Mich. 20804b–c.

Horizon and locality.—Middle Cambrian. Meagher limestone (*Ehmania* zone): *M3-1*, U.S.N.M. loc. *20k*, *Pole Creek;* U.S.N.M. loc. 159 (?), north of West Gallatin River. "Pagoda" limestone: 28-loose, Rock-Baldy Bear Creek ridge.

Distinguishing characters.—*Nisusia montanaensis* is characterized by its moderate, subequally biconvex profile and subdued paucicostellae. It differs from *N. deissi*, with which it is associated, in being much less convex and in having much weaker costellae.

Nisusia sp. 1
Plate 32, figures 7, 8

Known only from ventral valves. Outline transversely subrectangular; posterior margins slightly concave; cardinal extremities rounded; hinge less than width of valve at middle; sulcus broad, shallow; interarea long, concave, strongly apsacline; anterior slope convex marginally and concave on beak; apex highest point of valve; deltidium convex, covering one-third of delthyrium and extending as narrow wings along margins of delthyrium to its base; surface subdued to strongly costellate or fascicostellate, filate, and rarely concentrically lamellose; costellae without spines.

Figured specimen, Mont. T1176a.

Horizon and locality.—Middle Cambrian. Damnation limestone: 20-2, Scapegoat Basin.

Discussion.—Specimens of this species occur at only one locality and are fragmentary and poorly preserved. So far as can be determined, the species is most closely related to *N. lickensis* Bell, n. sp., differing from it in having less coarse costellae, which are without spines.

Nisusia sp. 2
Plate 32, figure 13

In the Damnation limestone of Scapegoat Basin occur two poor dorsal internal molds of *Nisusia* characterized by large size, strong convexity, great width relative to length, alate cardinal extremities, and coarse costellae. The molds, although badly weathered, indicate the existence of a low notothyrial platform. The specimens seem to be unique among species of *Nisusia* in Montana, but they are too poorly preserved to warrant specific identification. In form and outline they resemble some specimens of *Nisusia burgessensis* Walcott.

Figured specimen, Mont. T1179a.

Horizon and locality.—Middle Cambrian. Damnation limestone: 20-2, Scapegoat Basin.

Genus Wimanella Walcott, 1908

Wimanella Walcott, *1908*, Smithsonian Misc. Coll., vol. 53, no. 3, p. 98; Walcott, *1912*, U. S. Geol. Survey, Mon. 51, p. 745; Schuchert and Cooper, *1932*, Peabody Mus. Nat. History, Mem., vol. 4, pt. 1, p. 50.

Outline probably subquadrate to subsemicircular, but usually distorted during preservation; hinge in most species shorter than or subequal to width of shell at middle; anterior commissure rectimarginate to slightly sulcate; profile biconvex, convexity of ventral valve usually the greater; ventral interarea longer than that of dorsal valve; surface smooth except for subdued growth lines and ridges; shell calcareous, thin.

Ventral valve: Posterior margins concave; beak incurved, obtusely rounded to pointed; interarea concave to flat, moderately apsacline to nearly orthocline; delthyrium open. Delthyrial cavity deep, confined posteriorly by inflected brim of delthyrium and divided at apex by low short septum; dental plates present or absent; adductor muscular scars confined to distinctly impressed pit at anterior margin of delthyrial cavity; diductor tracks usually straight, narrow, diverging anteriorly from each side of apical septum and apparently continuous with pallial trunks; pallial trunks broad, diverging sharply from each side of adductor muscular impression, and apparently not reaching margin of valve; fine radial striae present in marginal portion of valve.

Dorsal valve: Posterior margin straight, usually shorter than width of valve at middle; profile moderately convex or nearly flat; interarea flat, about 45° anacline; notothyrium open, wide; apex obscure, marginal;

sulcus obscure or distinct. Notothyrial cavity shallow, often with low platform continued toward front of valve as broad ridge; cardinal process absent or obscure; brachiophores straight, projecting in line with notothyrial margins; radial striae present in marginal portion of valve.

Genotype, *Wimanella simplex* Walcott.

Species included.—The following species belong in *Wimanella* (emended): *Wimanella aurialis* Bell, n. sp.; *Wimanella catulus* Walcott, 1917; *Orthis? highlandensis* Walcott, 1886; *Wimanella rossensis* Resser, 1938; *Billingsella saffordi* Walcott, 1905; *Wimanella simplex* Walcott, 1908; *Wimanella taei* Resser and Endo, 1937; *?Wimanella shelbyensis* Walcott, 1908.

Distinguishing characters.—*Wimanella* is best characterized by its thin and smooth shell, subsemicircular outline, subequally to unequally biconvex profile, adductor muscular scar confined between anterior ends of diductor tracks, and straight brachiophores projecting in line with notothyrial margins.

Discussion.—Walcott (1908, p. 98) originally proposed the genus *Wimanella* to embrace the older and smooth species of the Billingsellidae. His choice of *W. simplex* as the genotype was unfortunate, as pointed out by Schuchert and Cooper (1932, p. 51), because poor preservation of the type specimens in soft shale has almost totally obscured their internal morphology. The present study is based on all of Walcott's original material and a few specimens since collected from the Gordon shale in Montana.

The lot of specimens which includes the holotype of *W. simplex* was collected from U.S.N.M. loc. 4v on Gordon Creek, Montana. It comprises five ventral valves, two of which have counterparts, and one dorsal valve (pl. 33, fig. 18) whose posterior margin has been crushed against an adjacent ventral valve. Enough of the margin can be seen, however, to suggest that it was straight, and that the apex was marginal. One ventral counterpart (pl. 33, fig. 17), the only internal impression in the collection, shows widely divergent pallial trunks. No specimens in the type lot show either external or internal radial lines.

In addition to the type lot, there are in the United States National Museum a dozen specimens (U.S.N.M. 97073) also labeled loc. 4v, which evidently have never been cited in the literature nor considered in connection with the description of *W. simplex*. Their occurrence in a somewhat more arenaceous matrix may explain why their convexity is much better preserved that that of the individuals in the type lot. There is little doubt that the specimens are conspecific with the holotype and its associated valves, although the ventral valves of the two lots differ somewhat in outline. The better preserved of these specimens (pl. 33, figs. 15, 19, 20) show that the ventral interarea is long and probably almost orthocline, the dorsal interarea short and somewhat anacline, the notothyrium wide and open, the notothyrial cavity shallow, with a platform from which a low median ridge extends anteriorly, the brachiophores slender, projecting in line with the notothyrial margins, the interior of the shell, particularly near the margins, radially striated, and a cardinal process absent or obscure. The large callosities shown in one dorsal internal mold (pl. 33, fig. 20), are thought to be the result of unusual preservation.

A collection of *W. simplex* from the Gordon shale at U.S.N.M. loc. 4w on Youngs Creek, Montana, has yielded the specimen (pl. 33, fig. 21) which served as the basis for Schuchert and Cooper's (1932, p. 51) description of the ventral musculature of *Wimanella*. In this musculature the diductor tracks are adjacent posteriorly, the adductor pit being restricted to a position between their anterior ends. The musculature is similar to that in *Wimanella highlandensis* (Walcott) (pl. 33, fig. 24), this species and *W. simplex* being used by Schuchert and Cooper as cogenotypes of *Wimanella*. Associated with the above mentioned specimen (pl. 33, fig. 21) is an impression (pl. 33, fig. 14) of a delthyrial cavity without a deep adductor pit but with two narrow divergent ridges, presumably the diductor tracks, crossing it. The fact that only one of the many ventral valves of *W. simplex* collected from the Gordon shale shows evidence of a deep adductor pit and strongly incised diductor impressions suggests that this valve may be either very gerontic or morphologically abnormal.

Schuchert and Cooper (1932, p. 50) say

a study of all of his (Walcott's) species of *Wimanella* at the U. S. National Museum shows the presence of faint radiating lines in shells conspecific with the genotype and in the actual types.

On the contrary, the specimens of *W. simplex* studied and figured by Walcott do not show radial striations of any kind, except, perhaps, on one internal mold (pl. 33, fig. 22). However, individuals in the lot of 12 topotypes (U.S.N.M. 97073) noted above show fine radial striations on the marginal portion of internal molds (pl. 33, figs. 15, 20). This type of striation is present in *Billingsella* (pl. 34, figs. 7, 9; pl. 35, fig. 18) and presumably is of pallial origin. No external radial striation could be demonstrated on specimens from the type locality or adjacent localities in the Gordon shale. The specimens of *W. rossensis* Resser from the Ross Lake shale are obviously smooth except for growth lines. Evidently Walcott's diagnosis of a smooth shell for *Wimanella* was correct, and Schuchert and Cooper interpreted radiating lines on internal molds as external features.

The Ross Lake shale member of the Cathedral dolomite[8] in British Columbia was correlated by Walcott (1917a) with the Gordon shale of Montana on the basis of a similar fauna, characterized by the trilobite genus *Albertella*. Walcott (1917a, pl. 4, figs. 7c, 7–7b, and 8–8c) recognized *W. simplex* in the Ross Lake shale at U.S.N.M. localities 35c, 63j, and 63m, respectively. Later Resser (1938, p. 10) assigned Walcott's specimens to two new species, *W. rossensis* and *W. walcotti*. A study of the numerous excellent specimens from these localities has convinced the writer that only one species is represented, that the name *W. rossensis*, applied to valves beautifully preserved in limestone, should be retained, and the name *W. walcotti*, applied to flattened valves in the enclosing shale be rejected as a synonym. The details of the ventral morphology presented in the writer's emendation of the genus have been derived from the study of several beautiful, undistorted, ventral internal molds (pl. 33, figs. 1–5) in the collection of *W. rossensis* from U.S.N.M. loc. 63m′ (limestone nodules in the shale of loc. 63m). The significant characters revealed by the molds are the distinctly rectangular adductor impression situated at the margin of the delthyrial cavity between the anterior ends of the diductor tracks but separated from them, and the short septum in the apex of the delthyrial cavity.

The writer believes that *Wimanella highlandensis* (Walcott) and *W. simplex* Walcott are congeneric, as first proposed by Schuchert and Cooper (1932, p. 50), but he also believes that their analysis was based on atypical individuals of these two species. The ventral valve (pl. 33, fig. 21) from the Gordon shale has been discussed above. Two ventral internal molds (pl. 33, figs. 23, 25) associated with the holotype (pl. 33, fig. 24) of *W. highlandensis*, the specimen on which Schuchert and Cooper based their analysis, show a muscular and pallial arrangement fundamentally like that in the holotype, but not nearly so strongly impressed. They show a short median septum in the delthyrial cavity, a distinct but not deep adductor impression anterior to it, broad pallial trunks diverging widely from each side of the muscular impression, and barely perceptible diductor tracks diverging from the posterior end of the septum. This arrangement is essentially identical with that found in the ventral valve of *W. rossensis* (pl. 33, fig. 4). The presence of dental plates in *W. highlandensis* and their absence in *W. simplex* and *W. rossensis* is considered to be a specific difference, subordinate to the muscular and pallial arrangement. The radial ribbing on *W. highlandensis* (Schuchert and Cooper, 1932, p. 51) occurs on internal molds (pl. 33, fig. 25) and not on the surface of the shell, which is smooth except for growth lines.

WIMANELLA AURIALIS Bell, n. sp.
Plate 33, figure 6

This species is characterized, so far as can be determined, by complete similarity to *W. simplex*, except that the cardinal extremities project as acute mucronations or ears. It has been collected at two localities, where it oc-

[8] In 1917 Walcott considered the Ross Lake shale to be a member of the Ptarmigan formation, but Deiss (1939b, p. 1002) has shown that the Ross Lake shale, characterized by the *Albertella* fauna, is a member of the Cathedral dolomite in Alberta and British Columbia. Collections from the Ross Lake shale at Ross Lake (Deiss, 1939b, p. 989, loc. C5c) and Mount Bosworth (Deiss, 1940, p. 747, loc. C6e), seen by the writer in June, 1940, contain excellent specimens of *Wimanella rossensis* Resser.

curs in soft shales. The specimens, all ventral valves, are completely flattened, but the outline and surface characters are well preserved. *W. aurialis* is similar in outline to *Diraphora borealis* (Walcott) but differs from it in having a smooth shell.

Holotype, Mont. T1192a.

Horizon and locality.—Middle Cambrian. Wolsey shale: *40-2, Big Snowy Mountains;* U.S.N.M. loc. 54z, probably the same locality; 45-1, Nixon Gulch.

WIMANELLA SIMPLEX Walcott
Plate 33, figures 13–22

Wimanella simplex WALCOTT, *1908*, Smithsonian Misc. Coll., vol. 53, no. 3, p. 101, pl. 10, fig. 2; WALCOTT (part), *1912*, U. S. Geol. Survey, Mon. 51, p. 748, pl. 89, figs. 2, 2a–e (not text fig. 64, p. 748); WALCOTT (part), *1917*, Smithsonian Misc. Coll., vol. 67, no. 2, pl. 4, figs. 6, 6a–c (not figs. 7, 7a–c, 8, 8a–c).

Outline probably subquadrate to subsemicircular; hinge shorter than or subequal to but never longer than width of shell at middle; cardinal extremities obtusely angular to rounded; anterior commissure rectimarginate to slightly sulcate; profile unequally biconvex, the greater convexity of ventral valve accentuated by prominent umbo; ventral interarea longer than dorsal; surface smooth except for subdued growth lines and lamellae; shell thin.

Ventral valve: Posterior margins concave; interarea concave to flat, moderately apsacline to orthocline; delthyrium open; beak incurved, obtusely pointed, obtusely rounded when flattened. Delthyrial cavity deep, confined posteriorly by inflected brim of delthyrium and divided at apex by low short septum; dental plates absent; adductor muscular scars confined to pit at anterior margin of delthyrial cavity; diductor muscular tracks straight, narrow, diverging anteriorly from apex of delthyrial cavity and apparently continuous with pallial trunks; pallial trunks broad, diverging rapidly from sides of adductor muscular impression and disappearing in marginal third of valve; each trunk composed of two parallel furrows separated by a ridge; radial striae present in marginal portion of valve.

Dorsal valve: Posterior margin straight, considerably shorter than width of valve at middle; interarea flat, about 45° anacline; notothyrium open; apex obscure, marginal; profile moderately convex or nearly flat; sulcus obscure or distinct. Notothyrial cavity shallow, often with low platform continued toward front of valve as a broad ridge; cardinal process apparently absent, its presence possibly being indicated by a low linear elevation; brachiophores straight, slender, projecting in line with notothyrial margins; radial striae present in marginal portion of valve.

Dimensions (mm.)

	Length	Width	Hinge width	L/W
Ventral valves:				
U.S.N.M. 52278a	6.17	8.7	7.7	0.71
U.S.N.M. 97073b	8.0	8.7	7.3	0.92
Dorsal valves:				
U.S.N.M. 97073a	10.7	12.7	13.3	0.84
U.S.N.M. 97073d	5.0	7.3	6.3	0.68

Holotype, U.S.N.M. 52278a; paratypes, U.S.N.M. 52278b, 52277a–d; hypotypes, U.S.N.M. 52278c, 52277e–f, 97073a–d, and Mont. T1184a.

Horizon and locality.—Middle Cambrian. Gordon shale: 20-1c, Scapegoat Basin; 23-1, Ahorn Creek; 53-1 (?), Kid Mt.; U.S.N.M. localities 4q, ridge between Gordon and Youngs Creeks; *4v, Gordon Creek;* 4w, Youngs Creek.

Distinguishing characters.—*Wimanella simplex* is best characterized by its convex ventral valve, having a prominent umbo and incurved beak, its moderately convex or nearly flat and sulcate dorsal valve, its compound (?) pallial trunks, and its lack of dental plates.

Discussion.—Walcott (1917b, p. 70), and later Resser (1938, p. 10) distinguished three species of *Wimanella* (*W. catulus* Walcott, *W. rossensis* Resser, and *W. walcotti* Resser) from the Cambrian rocks of Alberta and British Columbia, entirely on the basis of external shell form. The ventral valves in the type lot of specimens of *W. simplex* are flattened in soft shale and are subsemicircular in outline. The ventral valves in another group of specimens from the type locality occur only slightly flattened in a more arenaceous phase of the shale and are subquadrate in outline. The ventral valves from Youngs Creek are flattened in the soft Gordon shale but tend to be elongate-subrectangular. Apparently more than one species is indicated by these differing shell outlines.

However, among the numerous flattened ventral valves in the collections from the Ross Lake shale of Alberta and British Columbia, all three of the above-mentioned outlines are duplicated, as well as all transitions between them. In addition, many of the valves are distinctly asymmetrical, and in every instance the lines of foliation in the shale can be shown to parallel the direction of distortion in the shell. Likewise, the lines of foliation in the rock parallel the longitudinal axis of elongate valves and the transverse axis of excessively wide valves. Ventral valves, identical in all respects except outline and profile with those in the shale, occur in limestone nodules in the shale, are uniformly subequal in length and width, and are strongly convex. The discrepancy in outline between dorsal valves in the shale and in the limestone is less marked, evidently because the dorsal valves were originally only moderately convex. It must be concluded, therefore, that the combination of vertical compression and lateral distortion resulting from rock deformation has produced widely different outlines in convex shells whose outlines originally were similar. The writer's conclusion is that *W. catulus*, *W. rossensis*, and *W. walcotti* cannot be distinguished from *W. simplex* or from each other by means of shell outline. They are names applied to variations in shell form produced by mechanical forces subsequent to the burial of the shells. However, *W. rossensis* Resser may profitably be retained as a valid species because its well-defined internal characters cannot be compared with the poorly preserved structures in the specimens of *W. simplex* from the Gordon shale of Montana. In the writer's opinion *W. walcotti* Resser is a synonym of *W. rossensis*. The type specimens of *W. catulus* Walcott are too few and poorly preserved for adequate comparison with other species; it is reported from the Lower Cambrian, Mount Whyte formation, but almost certainly is Middle Cambrian in age.

Genus DIRAPHORA Bell, n. gen.

(Gr. διφράς, ridge; φόρός, bear)

Plate 33, figure 7

The genus *Diraphora* is proposed to embrace the primitive species of the Billingsellidae that apparently are like *Wimanella* except that they possess radial surface ornamentation.

Genotype, *Eoorthis bellicostata* Walcott, 1924, Smithsonian Misc. Coll., vol. 67, no. 9, p. 505, pl. 113, figs. 8–14.

The following species are referred to *Diraphora: Billingsella? anomala* Walcott, 1905; *Billingsella? appalachia* Walcott, 1905; *Eoorthis bellicostata* Walcott, 1924; *Wimanella borealis* Walcott, 1924; *Wimanella maladensis* Resser, 1939; *Protorthis nautes* Walcott, 1905; *Billingsella striata* Walcott, 1905.

Discussion.—A study of the primitive billingsellids represented in the United States National Museum collection shows that a number of Middle Cambrian species that heretofore have been assigned to a variety of genera apparently differ from *Wimanella*, as it is defined in this paper, only in possessing costellae. The dorsal cardinalia appear to be nearly identical in the two genera, but the delthyrial septum, if present at all in *Diraphora*, is less strongly developed than in *Wimanella*. All the species of *Diraphora* are thin-shelled, and most are represented by specimens poorly preserved in shale. The genotype was adequately described and figured by Walcott, but an additional ventral valve, showing the diductor tracks, continuous with the pallial trunks, is illustrated here (pl. 33, fig. 7).

DIRAPHORA STRIATA (Walcott)

Plate 33, figures 8–11

Billingsella striata WALCOTT, *1905*, U. S. Nat. Mus., Proc., vol. 28, p. 245; *1912*, U. S. Geol. Survey, Mon. 51, p. 764, pl. 86, figs. 4, 4a–c.

Ventral valve: Outline subquadrate; posterior margins slightly concave; beak obtusely pointed; cardinal extremities obtusely angular, lateral and anterior margins smoothly rounded; profile strongly convex, greatest convexity in posterior third of valve; beak strongly incurved; interarea long, concave, somewhat apsacline to nearly orthocline, depending on amount of concavity; delthyrium apparently open; surface evenly subdued costellate; shell thin, calcareous. Dental plates absent; teeth not observed; floor of deep delthyrial cavity crossed by two anteriorly trending narrow, divergent furrows (diductor tracks) which merge with the more divergent pallial trunks at margin of delthyrial cavity; each

pallial trunk is composed of two narrow furrows with a broad rounded ridge between them; pallial trunks disappear at margin of valve without bifurcation; marginal brim of valve closely grooved or plicate.

Dorsal valve: Represented by a single fragmentary exterior. Gently convex or flat, sulcate, closely costellate, filate.

Holotype, U.S.N.M. 52279a; paratypes, U.S.N.M. 52279b–d; hypotype, U.S.N.M. 52279e.

Horizon and locality.—Middle Cambrian. Meagher limestone: U.S.N.M. loc. 149a, Pole Creek.

Distinguishing characters.—*Diaphora striata* is characterized by its strongly convex ventral valve with incurved beak and apsacline to orthocline concave interarea.

Discussion.—The shell is quite thin. Because the outer surfaces of the shells adhere tenaceously to the matrix, internal molds are common; almost all specimens in the collection are internal molds of ventral valves. The single fragmentary dorsal exterior is so poorly preserved that its assignment to this species is uncertain.

Study of the ventral internal molds shows the palintrope to have been thick, apsacline to orthocline, strongly curved from apex to anterior margin, and unsupported by callus or dental plates. The teeth were not observed. Apparently the shell is continuous as a rim around the posterior end of the delthyrial cavity.

DIRAPHORA? sp.
Plate 33, figure 12

Known only from three ventral internal molds from different localities. Outline subquadrate; posterior margins concave; cardinal extremities obtusely angular; profile moderately convex, highest in posterior third of valve; apex slightly incurved; delthyrial cavity deep, bounded anteriorly by a low ridge; dental plates absent; diductor tracks straight, narrow, slightly divergent and continuous with faint pallial trunks; adductor scars present at anterior margin of delthyrial cavity; surface of molds covered by very fine radiating striae; more prominent ridges on molds indicate that valves were multicostellate.

Figured specimen.—Mont. T1183a.

Horizon and locality.—Middle Cambrian. Lower Meagher limestone: 47-2, Beaver Creek; U.S.N.M. localities 9h (52274), Beaver Creek, and 159 (unnumbered), north of West Gallatin River.

Discussion.—The molds are assigned tentatively to *Diraphora* because they lack dental plates, the diductor tracks are narrow

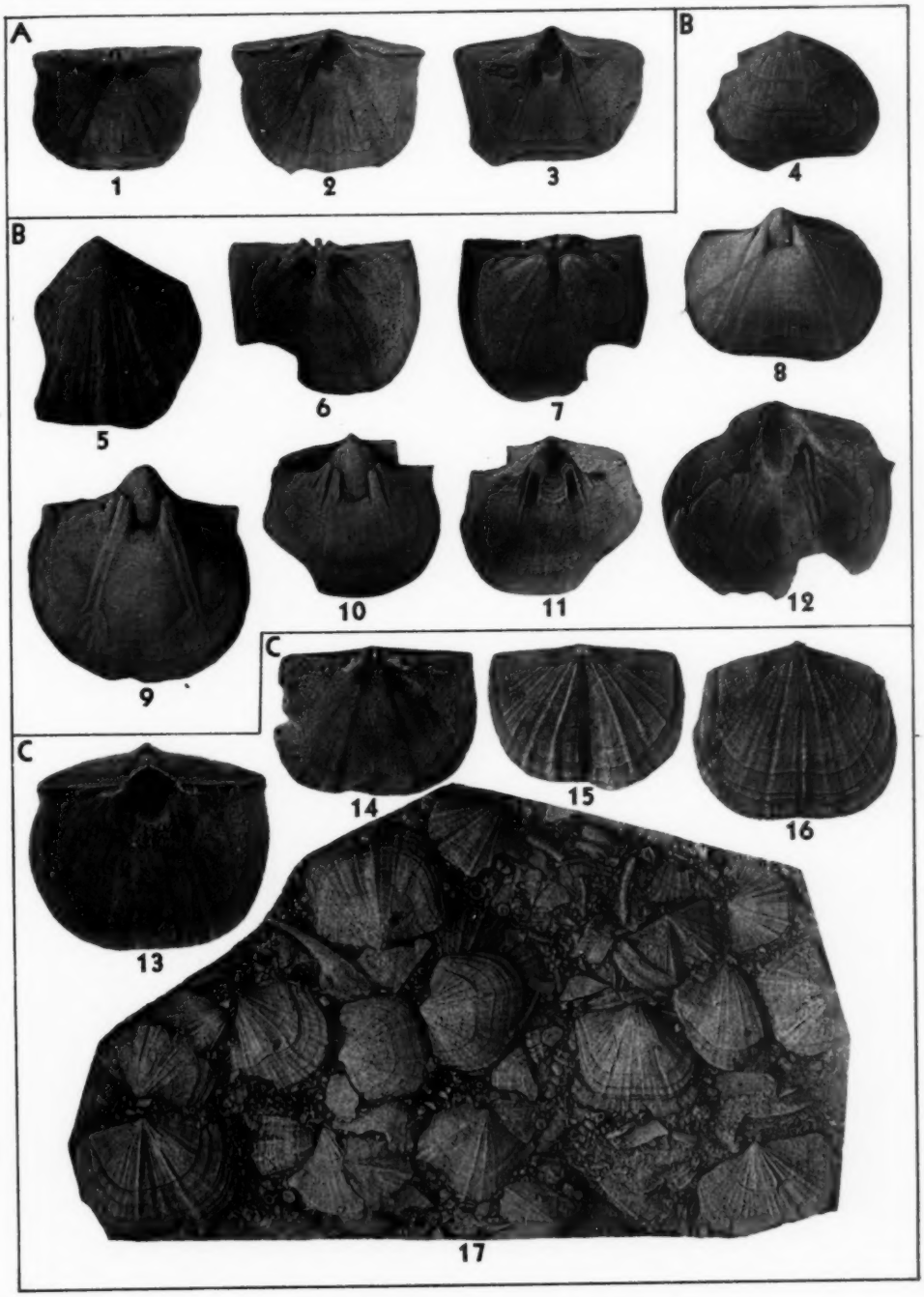
---

EXPLANATION OF PLATE 34

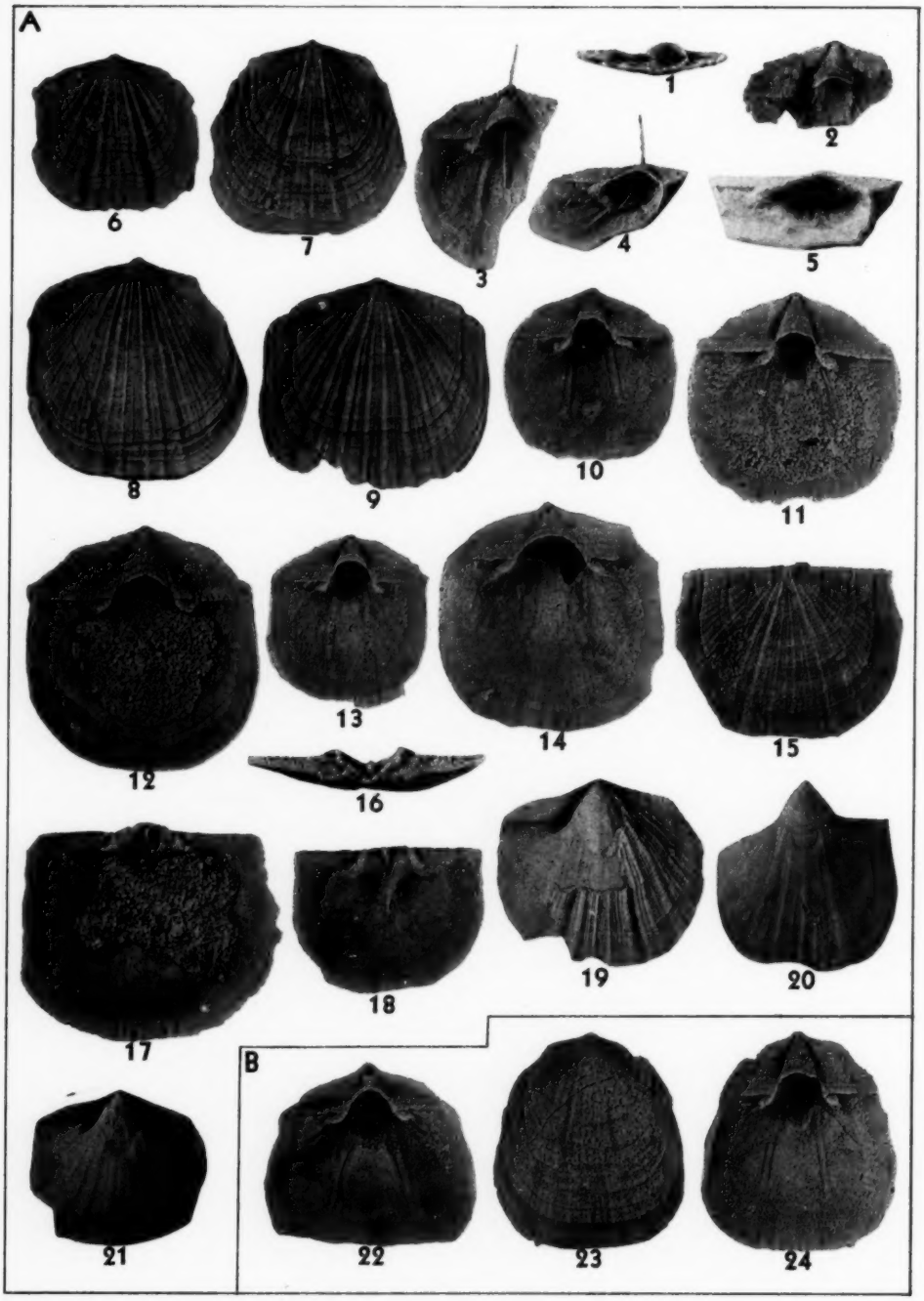
FIGS. *1–3*—*Billingsella alata* Bell, n. sp. *1*, *2*, Syntypes; interiors of incomplete dorsal and ventral valves, Mich. 20809a–b, ×3, loc. M1-4. *3*, Figured specimen (Mon. 51, pl. 86, fig. 3m, as *Billingsella plicatella*); interior of nearly complete ventral valve, showing high pseudospondylium and strong pallial trunks, U.S.N.M. 52266a, ×3, loc. 4j. Upper Cambrian: Snowy Range formation and Dry Creek shale. (p. 246)

4–12—*Billingsella plicatella* Walcott. *4*, Paratype (Mon. 51, pl. 86, fig. 3c); exterior of small sulcate ventral valve, U.S.N.M. 52263d, ×3, loc. 158. *5*, Paratype (Mon. 51, pl. 86, fig. 3); exterior of incomplete ventral valve, showing fila flexed toward apex at junction with median costella, U.S.N.M. 52263a, ×3, loc. 158. *6*, *7*, Paratype (Mon. 51, pl. 86, fig. 3l); clay squeeze and dorsal internal mold from which it was made, showing strong cardinal process and high ridge anterior to it, U.S.N.M. 52263l, ×3, loc. 158. *8*, Paratype (Mon. 51, pl. 86, fig. 3j); ventral internal mold, showing adductor track strongly constricted posteriorly, U.S.N.M. 52263j, ×3, loc. 158. *9*, Holotype (Mon. 51, pl. 86, fig. 3i); ventral internal mold, showing beautifully preserved pallial impressions, U.S.N.M. 52263i, ×3, loc. 158. *10*, *11*, Figured specimen; ventral internal mold and clay squeeze made from it, showing high pseudospondylium, Mont. T1177a, ×3, loc. 46-3. *12*, Figured specimen; incomplete ventral interior, showing distinct pallial markings, and adductor track strongly constricted posteriorly by encroaching diductor scars, Mont. T1177b, ×3, loc. 46-3. Upper Cambrian: Dry Creek shale. (p. 2 8)

13–17—*Billingsella exasperata* Bell, n. sp. *13*, Syntype; interior of ventral valve, Mont. T1172a, ×3, loc. 44-2. *14*, *15*, Syntypes; interior and exterior views of two dorsal valves, Mont. T1172b–c, ×3, loc. 44-2. *16*, Syntype; exterior of ventral valve, Mont. T1172d, ×3, loc. 44-2. *17*, Figured specimens; small slab of limestone bearing numerous dorsal and ventral valves of this species, Mich. 20807, ×2, loc. M1-4. Upper Cambrian: Dry Creek shale and Snowy Range formation. (p. 246)



Bell, Cambrian Brachiopoda



Bell, Cambrian Brachiopoda

and continuous with the pallial trunks, and the surfaces of the shells were costellate.

Genus BILLINGSELLA Hall, 1892

Billingsella HALL, *1892*, Paleontology New York, vol. 8, pt. 1, p. 230; WALCOTT, *1912*, U. S. Geol. Survey, Mon. 51, p. 749; SCHUCHERT and COOPER, *1932*, Peabody Mus. Nat. History, Mem., vol. 4, pt. 1, p. 48; ULRICH and COOPER, *1938*, Geol. Soc. America, Special Paper. 13, p. 72.

The excellent discussions by Schuchert and Cooper (1932, p. 48) and Ulrich and Cooper (1938, p. 72) have made *Billingsella* one of the best known Cambrian genera.The present study can add little information of generic significance.

The beautifully silicified specimens on which Ulrich and Cooper based their description of *B. perfecta* were obtained from the Teton Mountains in Wyoming, about 100 miles south of Crowfoot Ridge, Yellowstone National Park, from which were obtained the only silicified specimens of *Billingsella* in the writer's collections. At its type locality *B. perfecta* exhibits remarkably little variation in its characters. This is not true, however, of the billingsellids from Montana.

The writer had at his disposal four collections of *Billingsella* from measured sections, and in addition numerous United States National Museum collections from isolated and not accurately designated localities. From a study of these specimens, certain additions can be made to the knowledge of the development of the genus in Montana and adjacent areas. *Billingsella* is widespread geographically in Montana but limited to a narrow stratigraphic zone in the middle Upper Cambrian. It is the predominant brachiopod at almost all localities where it occurs, being associated with few representatives of *Eoorthis*, *Huenella*, *Ocnerorthis*, and *Otusia*. The most striking characteristic of *Billingsella*, as it is developed in south-central Montana and northwestern Wyoming, is the variability in form and ornamentation of the ventral valve. The ventral valve is characterized by a strongly convex to nearly flat profile; subcircular, subquadrate, transverse or elongate subrectangular outline; long or short interarea, relative to its width; long and convex, or short and flat deltidium; and strongly or weakly impressed muscular and pallial marks. In contrast, the dorsal valve varies almost not at all in its form and internal markings. The surface markings vary greatly in the relative development of costellae, parvicostellae, and fila.

Although certain of the above mentioned characters consistently occur together in such a way as to distinguish groups of shells that can be designated as of specific rank, there are many shells that partake of the characters of more than one of the specific groups. Shells from a single locality may vary widely from a norm, yet apparently identical forms are present at widely separated localities. The species of *Billingsella* described and illustrated in this paper are admittedly artificial in their composition and are presented only as representative nodes, from which considerable variation may be expected.

EXPLANATION OF PLATE 35

FIGS. *1–21—Billingsella perfecta* Ulrich and Cooper, *1*, *2*, Hypotype; two views of a fragmental ventral valve, showing details of the deltidium, Mont. T1170a, ×3, loc. 44-2. *3*, *4*, Hypotype; two views of an incomplete ventral valve, with hair passed through minute pedicle tube confined to the deltidium, Mont. T1170b, ×3, loc. 44-2. *5*, Enlarged view of same specimen tilted so as to see into apex, showing apical septum, Mont. T1170b, ×5, loc. 44-2. *6–9*, Hypotypes; ventral exteriors, showing slight variation in ornamentation, Mont. T1170c–f, ×3, loc. 44-2. *10–14*, Hypotypes; ventral interiors, showing slight variation in form of deltidium, Mont. T1170g–k, ×3, loc. 44-2. *15*, Hypotype; dorsal exterior, Mont. T1170l, ×3, loc. 44-2. *16*, *18*, Hypotype; posterior (×4) and interior (×3) views of a dorsal valve having especially stout brachiophores and cardinal process, Mont. T1170m, loc. 44-2. *17*, Hypotype; dorsal interior, showing strong chilidium, Mont. T1170n, ×3, loc. 44-2. *19*, *20*, Hypotypes; partial and incomplete ventral internal molds, Mich. 20801a–b, ×3, loc. M1-4. *21*, Hypotype; ventral internal mold, Mich. 20808a, ×3, loc. M2-1. Upper Cambrian: Dry Creek shale and Snowy Range formation. (p. 247)

22–24—Billingsella perfecta pyriformis Bell, n. var. *22*, Paratype; ventral interior, showing short deltidium, Mont. T1180b, ×3, loc. 44-2. *23*, *24*, Holotype; exterior and interior views of a complete ventral valve with a long interarea and deltidium, Mont. T1180a, ×3, loc. 44-2. Upper Cambrian: Dry Creek shale. (p. 247)

Apparently all occurrences of *Billingsella* in Montana and adjacent areas are essentially of the same age, and mark the greatest single period of orthid development in the Cambrian of this area. *Billingsella* occurs almost universally associated with *Eoorthis*, the subzones characterized by these genera in the upper Mississippi Valley province not being recognizable in Montana.

BILLINGSELLA ALATA Bell, n. sp.
Plate 34, figures 1–3

Billingsella plicatella Walcott. WALCOTT (part), *1912*, U. S. Geol. Survey, Mon. 51, pl. 86, figs. 3m, 3n (?).

Species known only from imperfect interiors. Outline transversely subrectangular with greatest width at hinge; cardinal extremities acutely angular, alate; profile moderately and subequally biconvex; surface apparently costellate and parvicostellate.

Ventral valve: Posterior margins slightly concave; apical angle 160°; interarea short in proportion to width, orthocline; adductor scar narrows rapidly and uniformly toward apex of valve; pseudospondylium high for the genus, pallial trunks straight, narrow, divergent.

Dorsal valve: Cardinal process strong; no muscular or pallial marks observed.

Dimensions (mm.)

	Length	Width	Hinge width	L/W
Ventral valve:				
Mich. 20809b....	7.0	8.2	9.0	0.85
Dorsal valve:				
Mich. 20809a....	5.7	8.0?	8.0?	0.71

Syntypes, Mich. 20809a-b; figured specimen: U.S.N.M. 52266a.

Horizon and locality.—Upper Cambrian. Dry Creek shale: 44-2 (?), Crowfoot Ridge, 46-3, Nixon Gulch; U.S.N.M. loc. 4j, head of Deep Creek, Yellowstone Park. Snowy Range formation: *M1-4, Beartooth Butte.*

Discussion.—The only other species of *Billingsella* that characteristically possesses alate cardinal extremities is *B. corrugata* Ulrich and Cooper, from which *B. alata* differs distinctly in surface ornamentation and in being decidedly more convex and smaller.

BILLINGSELLA EXASPERATA Bell, n. sp.
Plate 34, figures 13–17

Billingsella plicatella Walcott. WALCOTT (part), *1912*, U. S. Geol. Survey, Mon. 51, pl. 86, figs. 3b, 3f.

Outline subquadrate or transversely subrectangular; hinge line equal to, or slightly less than width of valve at middle; cardinal extremities rectangular to obtusely angular; profile moderately and subequally biconvex; anterior commissure sulcate; surface paucicostellate, strongly parvicostellate, and filate.

Ventral valve: Posterior margins straight or slightly convex; apical angle about 150°; umbo not noticeably swollen, anterior margin straight or slightly emarginate; flat median fold scarcely discernible, bordered by shallow furrows, and may disappear and be replaced anteriorly by shallow sulcus; interarea slightly longer than that in dorsal valve, very wide in proportion to length, flat, orthocline; apically perforated deltidium covers more than half of delthyrium. Costellae subdued, rounded; fila numerous; growth lamellae strong marginally. Adductor track wide, with subparallel sides; pallial trunks faintly impressed.

Dorsal valve: Outline transversely subrectangular; posterior margins straight; apical angle about 170°; cardinal extremities rectangular to obtusely angular; anterior margin emarginate, strongly sulcate; sulcus rounded in cross section, bordered by pair of strong costellae diverging from apex; interarea short, flat, strongly anacline; notothyrium open so far as observed. Surface paucicostellate, costellae decreasing in size from edge of sulcus to posterior margins; sulcus and flat intercostellate spaces strongly parvicostellate; fila distinct, close together. Notothyrial platform low; cardinal process and brachiophores short, stout; fine radiating ribs, presumably of pallial origin, present in marginal portion of shell.

Dimensions (mm.)

	Length	Width	Hinge width	L/W
Ventral valves:				
Mont. T1172a...	9.5	11.5	10.8	0.83
Mont. T1172d...	8.3	9.8	8.7	0.85
Dorsal valves:				
Mont. T1172b...	6.8	9.8	9.0	0.69
Mont. T1172c...	6.3	9.3	8.7	0.68

Syntypes, Mont. T1172a–d; figured specimens, Mich. 20807.

Horizon and locality.—Upper Cambrian. Dry Creek shale: *44-2 Crowfoot Ridge;* 46-3 (?), Nixon Gulch; U.S.N.M. localities 4j, 62r, 302f, 302g (?), all in Yellowstone Park;

147a, 151, 152, all in Bridger Range; 150a, 158, near Hillsdale; 302r (?), near Princeton. Snowy Range formation: M1-4, Beartooth Butte.

Discussion.—Billingsella exasperata is most similar to *B. weedi* but differs from it in outline and ornamentation and in having a faint ventral fold. Its convexity is intermediate between the slight convexity of *B. perfecta* and the strong convexity of *B. plicatella.*

Billingsella perfecta
Ulrich and Cooper
Plate 35, figures 1–21

Billingsella coloradoensis (Shumard). Walcott (part), *1912*, U. S. Geol. Survey, Mon. 51, pl. 85, figs. 1a, 1g, 1l, 1o, 1t, 1w.

Billingsella pepina (Hall). Schuchert and Cooper, *1932*, Peabody Mus. Nat. History, Mem., vol. 4, pt. 1, pl. 1, figs. 6, 13, 19, 21, 25.

Billingsella perfecta Ulrich and Cooper, *1936*, Jour. Paleontology, vol. 10, no. 7, p. 619; 1938, Geol. Soc. America, Special Paper 13, p. 74, pl. 7B, figs. 11–21.

Billingsella perfecta probably is the most completely known species of the genus and for practical purposes will likely come to typify *Billingsella*. The silicified specimens of *B. perfecta* from the type locality in the Teton Mountains, Wyoming, have uniformly thicker valves than the similarly preserved specimens from Crowfoot Ridge and have more deeply impressed muscular and pallial markings. The type specimens are remarkably uniform in shape and ornamentation, whereas those from Crowfoot Ridge vary within narrow limits. The surface ornamentation on the Montana specimens is better preserved, showing details visible on only a few of the types. The following emended characterization of the species is intended to include the additional information regarding variability and surface ornamentation derived from the present study.

Ventral valve: Outline subquadrate, subcircular, or elongate subrectangular; posterior margins slightly to strongly convex outward; hinge equal to or less than width of valve at middle; cardinal extremities obtusely angular or rounded; convexity slight, greatest at umbo; posterolateral flanks flattened or slightly concave; low flat median fold, defined by pair of furrows, disappears anteriorly, giving way in some valves to a faint sulcus; interarea orthocline, long with respect to width; apically perforated deltidium strongly convex, covering a third to one-half the delthyrium; costellae narrow, rounded, strongest on fold; intercostellate spaces flat, twice width of costellae, parvicostellate; fila vague or distinct, close together; growth lamellae present or absent Interior rather variable; adductor track long or short, slightly constricted posteriorly; pallial trunks narrow, straight, slightly divergent anteriorly.

Dorsal valve: Outline transversely subrectangular; hinge equal to or slightly less than width of valve at middle; cardinal extremities rectangular, obtusely angular, or rounded; convexity even, greater than in ventral valve; sulcus concave or flat-bottomed with steep sides, demarcated by pair of strong costellae diverging from apex; interarea vertical or strongly anacline; chilidium well-developed; costellae subdued in sulcus, distinct and close together on flanks; parvicostellae between costellae, particularly numerous in sulcus; fila faint or distinct, numerous. Brachiophores short, stout, oblique; notothyrial platform well-developed, usually extending anteriorly as axial ridge toward center of valve.

Dimensions (mm.)

	Length	Width	Hinge width	L/W
Ventral valves:				
Mont. T1170h...	10.0	10.0	9.3	1.00
Mont. T1170i...	11.3	10.8	10.3	1.05
Dorsal valves:				
Mont. T1170m..	6.7	9.0	8.7	0.74
Mont. T1170n...	9.7	12.7?	10.3	0.76

Hypotypes, Mont. T1170a–n, Mich. 20-801a–b, Mich. 20808a.

Horizon and locality.—Upper Cambrian. Dry Creek shale: 44-2, Crowfoot Ridge; 46-3, Nixon Gulch; U.S.N.M. localities 62r, 151e, 302g, all in Yellowstone Park; 4e, head of Jackson Creek, Teton Mountains, Wyoming; 154, near Hillsdale. Snowy Range formation: M1-4, Beartooth Butte; M2-1, Republic Mt.

Billingsella perfecta pyriformis
Bell, n. var.
Plate 35, figures 22–24

This variety, known only from ventral valves, differs from *Billingsella perfecta* in having a more convex and elongate shell, greatest width in anterior third of valve, more convex posterior margins, relatively

longer interarea, and more common rugose lamellae. In this variety the deltidium is either very convex and covers more than one-half of the delthyrium, or it is slightly convex and covers less than one-third of the delthyrium.

Dimensions (mm.)

	Length	Width	Hinge width	L/W
Ventral valve:				
Mont. T1180a...	10.0	9.3	7.6	1.08

Holotype, Mont. T1180a; paratype, Mont. T1180b.

Horizon and locality.—Upper Cambrian. Dry Creek shale: *44-2* and U.S.N.M. loc. 302g, both on *Crowfoot Ridge*.

Discussion.—The comparatively slight difference in structure between these valves and those of *B. perfecta*, together with the fact that no dorsal valves and only a few ventral valves are known, has led to the proposal of a variety of *B. perfecta* rather than a new species.

BILLINGSELLA PLICATELLA Walcott
Plate 34, figures 4–12

Billingsella plicatella WALCOTT, *1905*, U. S. Nat. Mus., Proc., vol. 28, p. 240; WALCOTT (part), *1912*, U. S. Geol. Survey, Mon. 51, p. 759, pl. 86, figs. 3, 3a, 3c, 3e (?), 3g–l (not figs. 3b, 3f = *B. exasperata* Bell, n. sp.; 3m, 3n = *B. alata* Bell, n. sp.; 3d = *Eoorthis* sp.)

Outline subquadrate or subcircular; hinge equal to or slightly less than width of shell at middle; cardinal extremities obtusely rounded; profile unequally biconvex, convexity of ventral valve being considerably the greater; surface multicostellate, with numerous parvicostellae in interspaces, crossed by numerous distinct fila.

Ventral valve: Profile evenly and strongly convex, greatest height at middle of valve; sulcus present or absent; interarea longer than dorsal, orthocline or slightly apsacline; character of deltidium unknown; two strong costellae diverge anteriorly from apex, a single costella of equal strength being implanted between them; fila flex sharply toward apex at junction with three major costellae; costellation subdued and parvicostellae numerous in sulcate valves. Adductor track strongly constricted posteriorly by excessively large diductor impressions, abruptly expanded anteriorly into deeply incised subquadrate impression, and raised above floor of valve on a deposit of callus; vascula media (Öpik, 1934, pp. 38–40) strongly impressed, straight, originating lateral to rectangular adductor scar at anterior margins of diductor impressions, diverging at about 30° and bifurcating near margin of valve into inner secondary vascula which coalesce at median line of valve, and lateral secondary

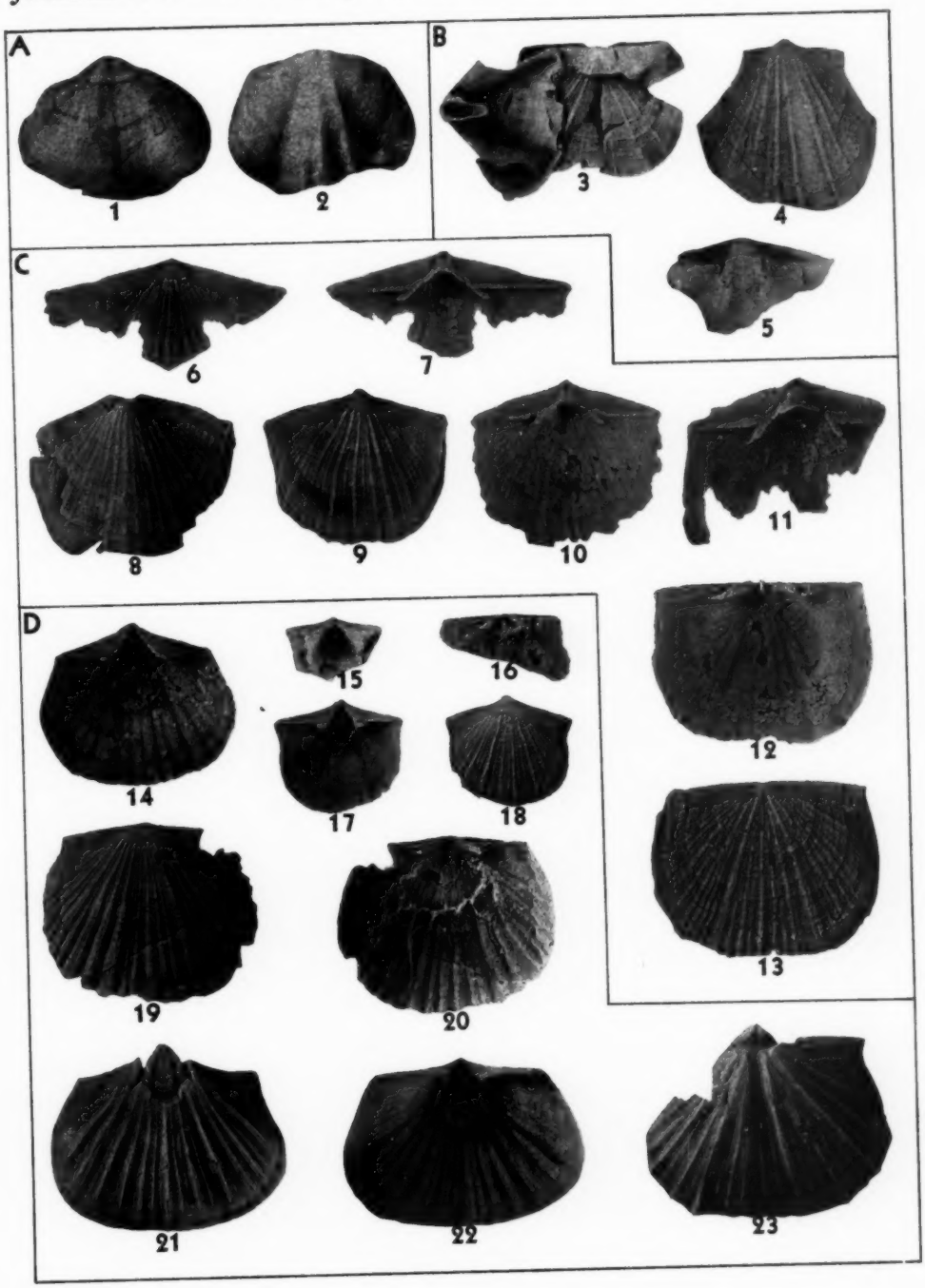
EXPLANATION OF PLATE 36

FIGS. *1, 2*—*Huenella abnormis* (Walcott). Holotype (Mon. 51, pl. 103, fig. 2a); ventral exterior, U.S.N.M. 52462b, ×3, loc. 4j. *2*, Paratype (Mon. 51, pl. 103, fig. 2e); dorsal exterior, U.S.N.M. 52462e, ×3, loc. 4j. (see also *3*) Upper Cambrian: Dry Creek shale. (p. 254)

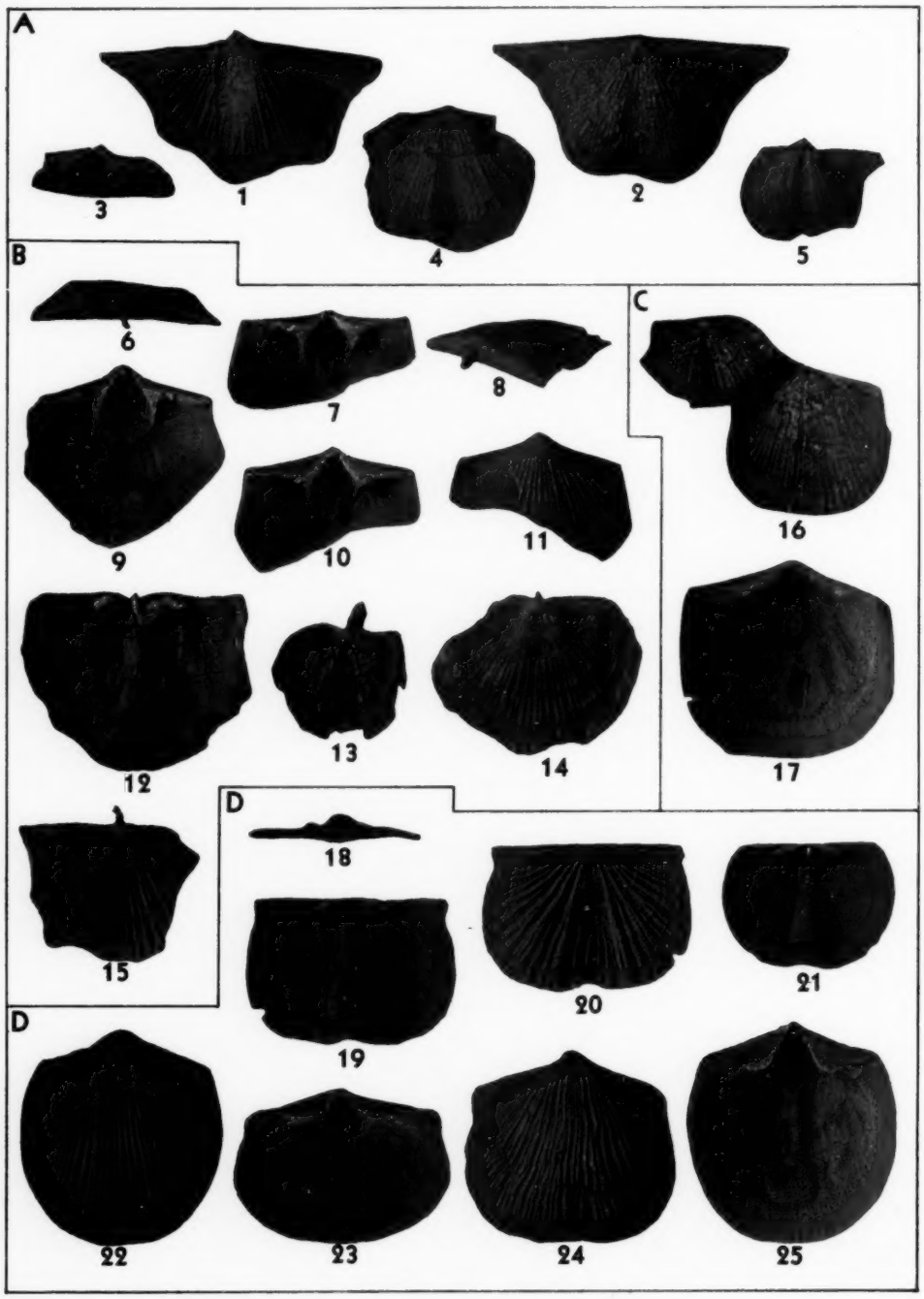
3–5—*Billingsella weedi* (Walcott). *3*, Syntype (Walcott, 1924, pl. 120, fig. 7, as *Huenella weedi*); dorsal exterior, associated with an incomplete ventral interior of *Huenella abnormis*, U.S.N.M. 69798c, ×3, loc. 302g. *4*, Syntype (Walcott, 1924, pl. 120, fig. 8, as *Huenella weedi*); incomplete ventral exterior, U.S.N.M. 69798a, ×3, loc. 302g. *5*, Hypotype; incomplete ventral internal mold, U.S.N.M. 69798d, ×3, loc. 302g. Upper Cambrian: Dry Creek shale. (p. 250)

6–13—*Billingsella radiata* Bell, n. sp. *6, 7*, Syntype; exterior and interior views of a fragmental ventral valve, Mont. T1171a, ×3, loc. 44–2. *8*, Figured specimen; incomplete ventral exterior, Mich. 20802a, ×3, loc. M2-1. *9*, Syntype; ventral exterior, Mont. T1171b, ×3, loc: 44-2. *10, 11*, Syntypes; ventral interiors, Mont. T1171c–d, ×3, loc. 44-2. *12, 13*, Syntypes; interior and exterior of two dorsal valves, Mont. T1171e–f, ×3, loc. 44-2. Upper Cambrian. Dry Creek Shale and Snowy Range formation. (p. 250)

14–23—*Eoorthis remnicha* (Winchell). *14*, Figured specimen; ventral interior, Mont. T1173a, ×1.5, loc. 44-2. *15*, Figured specimen; interior of ventral apex, showing apical callosity, Mont. T1173e, ×3, loc. 44-2. *16*, Figured specimen; incomplete dorsal interior showing exceptionally well developed cardinal process, Mont. T1173d, ×3, loc. 44–2. *17, 18*, Figured specimen; interior and exterior of a ventral valve, Mont. T1173c, ×3, loc. 44-2. *19, 20*, Figured specimen; dorsal exterior and interior, Mont. T1173b, ×2, loc. 44-2. *21, 22*, Figured specimen; ventral internal mold and clay squeeze made from it, showing strong dental plates and high pseudospondylium, Mich. 20800a, ×3, loc. M2-1. *23*, Figured specimen; incomplete dorsal internal mold, showing adductor muscular impressions and strong cardinal process, Mont. T1175a, ×3, loc. 46-3. Upper Cambrian: Dry Creek shale and Snowy Range formation. (p. 254)



Bell, Cambrian Brachiopoda



Bell, Cambrian Brachiopoda

vascula which parallel margin of valve, becoming the vascula arcuata.

Dorsal valve: Represented in type lot only by immature specimens from which finer ornamentation has been removed by abrasion. Outline transversely subrectangular; anterior margin sulcate; interarea short, flat, strongly anacline; surface paucicostellate. Notothyrial platform high, extending anteriorly as strong ridge; cardinal process and brachiophores short and stout. Marginal brim of both valves abruptly deflected outward.

Dimensions (mm.)

	Length	Width	Hinge width	L/W
Ventral valve:				
U.S.N.M. 52263i.	10.3	10.5	8.5	0.98
Dorsal valve:				
U.S.N.M. 52263l.	7.2	9.6	9.0	0.75

Holotype, U.S.N.M. 52263i; paratypes, U.S.N.M. 52263a, b, d, g, h, j–l; figured specimens, Mont. T1177a–b.

Horizon and locality.—Upper Cambrian. Dry Creek shale: 46-3, Nixon Gulch; U.S.-N.M. localities 4j, Yellowstone Park; 150a, 153, 153a (?), 154, 156b, 157, *158*, all *near Hillsdale;* 151, 151a (?), 152, all in Bridger Range; 302r (?), near Princeton. Snowy Range formation: M2-1, Republic Mt.

Distinguishing characters.—*Billingsella plicatella* is characterized by its ventral valve being considerably more convex than the dorsal, adductor scar strongly constricted posteriorly, pseudospondylium and pallial marks exceptionally well developed, fila flexed toward apex at junction with three major costellae on ventral valve, and marginal brim of both valves slightly deflected outward.

Discussion.—*Billingsella plicatella* is readily separated from all associated species of the genus by the extreme convexity of the ventral valve.

The type collection of *B. plicatella*, as here restricted, comprises four excellent internal molds of ventral valves, one of which is the holotype, three poor ventral exteriors, one poor dorsal exterior, and one good dorsal internal mold. The holotype is a large valve, and only one of the ventral exteriors approaches it in size; the other ventral and dorsal exteriors are much smaller, evidently being immature individuals. The large ventral exterior is the only specimen on which the finer details of the surface ornamentation are preserved.

Possibly two species, or at least varieties, characterized by sulcate and nonsulcate

---

EXPLANATION OF PLATE 37

FIGS. *1–5—Otusia sandbergi* (Winchell). *1*, Figured specimen (Mont. 51, pl. 93, fig. 4); ventral exterior, U.S.N.M. 35214a, ×4, loc. 302f. *2*, Figured specimen; partly exfoliated dorsal exterior, Mont. T1182a, ×3, loc. 46-3. *3*, *4*, Figured specimen; interior and exterior of incomplete dorsal valve, showing short brachiophores, Mich. 20806a, ×3, loc. M1-4. *5*, Figured specimen; incomplete dorsal internal mold, showing eoorthoid notothyrial cavity without cardinal process, Mont. T1182b, ×3, loc. 46-3. Upper Cambrian: Dry Creek shale and Snowy Range formation. (p. 251)

6–15—Ocnerorthis monticola Bell, n. gen., n. sp. *6*, *8*, *15*, Syntype; posterior, oblique-posterior and exterior views of dorsal valve in which cardinal process is exceptionally developed, Mont. T1174c, ×3, loc. 44–2. *7*, *10*, Syntype; interior views of incomplete ventral valve, the former tilted so as to show strong dental plates, Mont. T1174a, ×4, loc. 44-2. *11*, Exterior view of same valve, Mont. T1174a, ×4, loc. 44-2. *9*, Syntype; ventral interior, Mont. T1174d, ×3, loc. 44-2. *12*, Syntype; dorsal interior, showing sturdy brachiophores and cardinal process, Mont. T1174b, ×3, loc. 44-2. *13*, *14*, Syntypes; dorsal exteriors, the former with greatly extended cardinal process, Mont. T1174e–f, ×3, loc. 44-2. Upper Cambrian: Dry Creek shale. (p. 253)

16, *17—Ocnerorthis? iddingsi* (Walcott). *16*, Exteriors of adjoining ventral and dorsal valves; ventral valve the holotype (Mon. 51, pl. 91, fig. 3) U.S.N.M. 52340a, dorsal valve a paratype (Mon. 51, pl. 91, fig. 3a) U.S.N.M. 52340b; ×3, loc. 302c. *17*, Paratype (Mon. 51, pl. 91, fig. 3b); badly damaged ventral interior, U.S.N.M. 52340c, ×3, loc. 302c. Upper Cambrian: Dry Creek shale. (p. 253)

18–25—Ocnerorthis cooperi Bell, n. gen., n. sp. *18*, *21*, Syntype; posterior and interior views of dorsal valve, showing anterior end of strong cardinal process embedded in long median ridge, U.S.N.M. 96802d, ×3, *19*, *20*, Syntype; dorsal interior and exterior, U.S.N.M. 96802c, ×3, *22*, *25*, Syntype; ventral exterior and interior, U.S.N.M. 96802a, ×3. *23*, *24*, Syntype; ventral interior and exterior, the former tilted to show absence of dental plates, U.S.N.M. 96802b, ×3. Upper Cambrian: Snowy Range formation, Torrey Creek, Wind River Range, Wyoming. (p. 252)

ventral valves, are represented in the type lot. Until a more adequate collection of specimens from the type area is available for study, it seems best to leave the species essentially as Walcott presented it.

BILLINGSELLA RADIATA
Bell, n. sp.
Plate 36, figures 6–13

This species is close to *B. perfecta* but differs in usually being larger and in having a thinner shell, wider and narrower ventral interarea, wider delthyrial angle, shorter deltidium, and more conspicuous costellae. The ventral hinge line is usually wider than, sometimes equal to, and never less than, the width of the valve at the middle; cardinal extremities rectangular or acutely angular to slightly mucronate. Internally, the brachiophores are longer, thinner, and more oblique than in *B. perfecta*, the notothyrial platform being scarcely discernible. The costellae are more angular, closer together, and more uniformly distributed on the flanks of the valves; on some specimens they resemble plicae, being readily visible on the inner surface of the shell. The thinness of the shell, a consistent character even in large valves, apparently allows no distinct impressions of muscular or pallial marks.

Dimensions (mm.)

	Length	Width	Hinge width	L/W
Ventral valves:				
Mont. T1171b...	7.6	8.2	8.8	0.93
Mont. T1171c...	8.3	9.0	9.2	0.92
Dorsal valves:				
Mont. T1171e...	8.5	10.8	9.5	0.78
Mont. T1171f...	7.7	10.3	9.8	0.77

Syntypes, Mont. T1171a–f; figured specimen: Mich. 20802a.

Horizon and locality.—Upper Cambrian. Dry Creek shale: *44-2, Crowfoot Ridge.* Snowy Range formation: M1-4, Beartooth Butte; M2-1, Republic Mt.

Discussion.—Although *Billingsella radiata* is typically larger than *B. perfecta*, the thinness of the valves caused a high mortality during preparation. Consequently only the thicker cardinal portions of the valves are usually preserved. This species resembles *B. exasperata* in having a narrow ventral interarea, but differs distinctly from it in outline, convexity, and radial ornamentation.

BILLINGSELLA WEEDI (Walcott)
Plate 36, figures 3–5

Huenella? weedi WALCOTT, *1924*, Smithsonian Misc. Coll., vol. 67, no. 9, p. 522, pl. 120, figs. 5, 7, 8.

The type specimens of this species are associated with numerous specimens of *Huenella abnormis* (Walcott) on two small slabs of limestone from the north slope of Crowfoot Ridge. They comprise two somewhat weathered ventral exteriors, one broken dorsal exterior, and several fragments of ventral and dorsal valves. On the reverse side of one slab is an internal mold of the apical portion of a ventral valve, which evidently was not noted by Walcott.

Although the specimens of *Billingsella weedi* are inadequate for a complete description, they appear to be sufficiently distinct from other species in Montana and Wyoming to justify retention of Walcott's name. The following emendation of Walcott's very meager description is based only on the types of the species, which at present is known only from the type locality.

Ventral valve: Outline probably subquadrate or elongate subrectangular; hinge probably slightly less than width of valve at middle; posterior margins straight; apical angle nearly 180°; umbo swollen, posterolateral flanks flattened to concave; profile moderately convex, with greatest height slightly posterior to middle; surface paucicostellate, broad intercostellate spaces closely parvicostellate; no axial fold or furrows; interarea very wide in proportion to length, flat, slightly apsacline; pseudospondylium high; delthyrium and deltidium, muscular and vascular impressions not visible.

Dorsal valve: Apparently subquadrate; hinge shorter than width of valve at middle; profile nearly flat; interarea vertical, short; notothyrium open; cardinal process present; surface paucicostellate, not over three or four costellae on each flank; intercostellate spaces closely parvicostellate; character of sulcus unknown but apparently shallow.

Dimensions (mm.)

	Length	Width	Hinge width	L/W
Ventral valve:				
U.S.N.M. 69798a	8.7?	8.7?	?	1.0
Dorsal valve:				
U.S.N.M. 69798c	6.0	8.3?	7.0	0.72

Syntypes, U.S.N.M. 69798 a–c; hypotype, U.S.N.M. 69798d.

Horizon and locality.—Dry Creek shale: U.S.N.M. loc. 302g, north slope of Crowfoot Ridge.

Discussion.—*Billingsella weedi* most closely resembles *B. exasperata*, but differs from it in being elongate subrectangular in ventral outline and in having a different ornamentation; from *B. perfecta* it differs in being more convex and differently ornamented and in lacking a ventral fold; from *B. plicatella* it differs in being much less convex.

Genus OTUSIA Walcott, 1905
OTUSIA SANDBERGI (Winchell)
Plate 37, figures 1–5

Orthis sandbergi WINCHELL, *1886*. Geol. and Nat. History Survey Minnesota, 14th Ann. Rept., p. 318, pl. 2, figs. 8, 9.

Orthis? sandbergi WALCOTT, *1899*, U. S. Geol. Survey, Mon. 32, pt. 2, p. 452, pl. 61, figs. 2, 2a–d.

Billingsella (*Otusia*) *sandbergi* WALCOTT, *1905*, U. S. Nat. Mus., Proc., vol. 28, p. 246.

Otusia sandbergi WALCOTT, *1912*, U. S. Geol. Survey, Mon. 51, p. 769, pl. 93, figs. 4, 4a–d.

This species is poorly represented in the writer's collections by a few dorsal valves, which closely resemble specimens from near the type locality in Minnesota. Walcott's (1912, p. 769) definition of the species apparently was based primarily on specimens from Yellowstone Park that, in the writer's opinion may belong to *Billingsella* rather than to *Otusia*. However, because comparison could not be made directly with the types, and because the specimens from Montana give little information of the internal morphology, no change is made in present designations. It should be pointed out that the writer's specimens, which in external appearance resemble individuals of *O. sandbergi* from the Upper Mississippi Valley more closely than do those from Yellowstone Park, possess a notothyrial cavity (pl. 37, fig. 5) like that in *Eoorthis remnicha* (Winchell), whereas the specimens from Yellowstone Park have a strong cardinal process like that in *Billingsella*.

Figured specimens.—Mont. T1182a–b; Mich. 20806a; U.S.N.M. 35214a.

Horizon and locality.—Upper Cambrian. Dry Creek shale: 46-3, Nixon Gulch; U.S.N.M. loc. 302f, Elk Pass, Yellowstone Park. Snowy Range formation: M1-4, Beartooth Butte.

Genus OCNERORTHIS Bell, n. gen.
(Gr. *ὀκνηρός*, hesitating; *Orthis*)

Outline subquadrate; profile unequally biconvex to planoconvex; ventral interarea longer than dorsal; anterior commissure sulcate; surface costellate.

Ventral valve: Interarea concave, nearly orthocline in the genotype, strongly apsacline in *O. monticola;* beak incurved; delthyrium open except for small callosity at apex. Delthyrial cavity deep; teeth strong, oblique or nearly horizontal; dental plates absent in the genotype, present in *O. monticola;* musculature as in *Billingsella* and *Eoorthis;* pallial trunks subparallel, straight.

Dorsal valve: Interarea strongly anacline to hypercline; notothyrium open. Brachiophores as in *Billingsella* and *Eoorthis;* notothyrial platform strongly developed, extending anteriorly as a low ridge, which widens and often thickens near the margin; cardinal process short, stout, orthoid; musculature as in *Billingsella* and *Eoorthis*.

Genotype, *Ocnerorthis cooperi* Bell, n. sp.

Distinguishing characters.—*Ocnerorthis* is characterized by its strongly convex, eoorthoid ventral valve, flat or slightly convex dorsal valve, a strong dorsal ridge, which widens anteriorly and extends nearly to the margin, and a costellate or parvicostellate surface.

Discussion.—An anomolous combination of characters is exhibited by *Ocnerorthis*. The ventral valve is distinctly eoorthoid in its form, particularly in *O. monticola*, in which the resemblance is carried to an extreme by the presence of well-developed dental plates and a strongly apsacline interarea. In contrast, the dorsal valve, with its stout brachiophores and high notothyrial platform anterior to the strong cardinal process, bears a close resemblance to *Billingsella*. Young dorsal valves of *Ocnerorthis* and *Billingsella* are almost indistinguishable, except for the broad median elevation extending nearly to the anterior margin in the former. These hybrid relationships, together with wide specific fluctuations, as indicated by variation in the cardinal extremities, length of hingeline, and presence or absence of dental plates, suggests an unstable organism

distantly related to both *Billingsella* and *Eoorthis*.

Two genera may be represented by *O. cooperi* and *O. monticola*. The similarity of the dorsal valves of these species certainly indicates a family, though perhaps not necessarily a generic relationship. Each species is known with certainty from a single locality, and although some specimens are very well preserved, they are few in number. Because the material for study is so limited, and the systematic significance of dental plates among these primitive orthids is not understood, it seems best to include both species in one genus rather than to establish two monotypic genera. The generic diagnosis has been prepared principally from the genotype, *O. cooperi*.

OCNERORTHIS COOPERI Bell, n. sp.
Plate 37, figures 18–25

Outline subquadrate or slightly elongate ovate; cardinal extremities rounded or slightly mucronate; hinge equal to or less than width of shell at middle; anterior commissure sulcate, sometimes slightly emarginate; profile planoconvex, greatest height being at middle of ventral valve; surface coarsely and evenly fascicostellate in ventral valve, fascicostellate and parvicostellate in dorsal valve.

Ventral valve: Posterior margins slightly concave, apical angle 135°–140°; interarea longer than that of dorsal valve, concave, orthocline or slightly apsacline; beak incurved; delthyrium open; surface coarsely and evenly fascicostellate. Delthyrial cavity wide and deep, with subtriangular apical callosity like that in *Billingsella perfecta;* teeth flat, elongate, nearly horizontal, continuous with palintrope; dental plates absent; adductor track broad, having subparallel sides, and extending past diductor scars; pallial trunks broad, straight, diverging slightly from their origin in the diductor scars, and reaching nearly to margin of valve.

Dorsal valve: Outline obtusely subquadrate; posterior margin straight; anterior margin emarginate; apex minute, marginal; sulcus increases in depth from apex to margin, its abrupt sides diverging at about 30°; interarea very short, anacline; notothyrium open; flanks of valve fascicostellate; sulcus parvicostellate, with a few widely separated costellae present anteriorly in some specimens. Notothyrial cavity shallow; brachiophores linear, divergent, nearly parallel to cardinal margin, and supported by two low ridges of callus, which converge and fuse at anterior end of cardinal process into a single low rounded elevation; elevation widens and thickens anteriorly, ending abruptly near margin of valve; cardinal process a short vertical plate, embedded anteriorly in the low median ridge.

Dimensions (mm.)

	Length	Width	Hinge width	L/W
Ventral valves:				
U.S.N.M. 96802a	10.0	9.6	8.0	1.04
U.S.N.M. 96802b	9.2	9.8	8.4	0.94
Dorsal valves:				
U.S.N.M. 96802c	6.7	9.8	9.0	0.68
U.S.N.M. 96802d	5.9	8.0	6.1	0.74

Syntypes, U.S.N.M. 96802a–d.

Horizon and locality.—Upper Cambrian. Snowy Range formation: Torrey Creek, Wind River Range, Wyoming.

Distinguishing characters.—Ocnerorthis cooperi is characterized by its lack of dental plates, its concave, nearly orthocline ventral interarea, and the conspicuous elevation and widening of the median dorsal ridge.

Discussion.—This species differs from *O. monticola* in its lack of dental plates, and in the orientation of the ventral interarea.

The subtriangular deposit of callus at the apex of the delthyrial cavity seems identical in form and position to that present in *Billingsella* (Ulrich and Cooper, 1938, p. 72). The callus, which extends anteriorly as a short septum, evidently strengthened the apex of the pseudodeltidium in *Billingsella*, but its function in *Ocnerorthis*, except perhaps as a foundation for pedicle attachment, is not apparent.

A pair of conspicuous callosities or scars occur at the anterior end of the median ridge in one dorsal valve (pl. 37, fig. 19). If they are muscular scars, which appears improbable, they are relatively farther forward than in any species of brachiopod with which the writer is familiar. In the same dorsal valve are a pair of short, narrow arcuate ridges, convex toward the cardinal extremities and extending anterolaterally from a position abutting the terminal ends

of the brachiophores. They may represent pallial trunks, but nothing similar is known among Cambrian orthoids.

OCNERORTHIS? IDDINGSI (Walcott)
Plate 37, figures 16, 17

Orthis? remnicha Winchell. WALCOTT (part), *1899*, U. S. Geol. Survey, Mon. 32, pt. 2, pl. 62, figs. 1a–b.
Orthis (*Plectorthis*) *iddingsi* WALCOTT, *1905*, U. S. Nat. Mus., Proc., vol. 28, p. 264.
Eoorthis iddingsi WALCOTT, *1912*, U. S. Geol. Survey, Mon. 51, p. 780, pl. 91, figs. 3, 3a–b.

The specimens from the type locality are very poorly preserved, but the form of the valves, and the surface ornamentation seem to place the species in *Ocnerorthis*. It seems most likely that the specimens are conspecific with *O. monticola*, but without a knowledge of either the ventral or dorsal internal structure, an assignment to *Ocnerorthis* cannot be made with any degree of certainty. Consequently, it seems best to restrict the name *O.? iddingsi* to the type specimens.

Holotype, U.S.N.M. 52340a; paratypes, U.S.N.M. 52340b–c.

Horizon and locality.—Upper Cambrian. Dry Creek shale: U.S.N.M. loc. 302c, south side of Gallatin Valley, Yellowstone Park, Wyoming.

OCNERORTHIS MONTICOLA Bell, n. sp.
Plate 37, figures 6–15

Outline obtusely subquadrate; cardinal extremities rounded or obtusely angular; hinge less than width of shell at middle; anterior commissure rectimarginate or slightly sulcate; profile unequally biconvex, almost planoconvex, greatest height being at middle of ventral valve; ventral interarea longer than dorsal; surface parvicostellate.

Ventral valve: Posterior margins slightly concave; apical angle about 140°; interarea concave, strongly apsacline; beak incurved; delthyrium open except for very small callosity in apex; surface evenly parvicostellate. Delthyrial cavity deep; dental plates strong, receding, converging slightly and fusing with floor of valve to form a callosity or pseudospondylium, on which adductor scars are elevated; teeth short, roughly triangular in cross section; adductor track narrow, with slightly diverging sides, projecting beyond diductor scars; pallial trunks wide, slightly divergent.

Dorsal valve: Outline subquadrate to ovate; posterior margin straight, equal to or less than width of valve at middle; interarea anacline or hypercline; cardinal extremities rounded or obtusely angular; lateral and anterior margins evenly rounded; sulcus usually present, shallow, with gently sloping sides; surface rather evenly costellate, the costellae on margins of sulcus slightly stronger. Notothyrial cavity shallow; brachiophores short, very stout, cupped on posterolateral margins to form dental sockets and supported by two low ridges of callus, which converge and fuse at anterior end of cardinal process into a single low, broad, rounded elevation; elevation widens slightly and disappears near margin of valve; cardinal process stout, vertical, its anterior end embedded in callus of median ridge and often projecting posteriorly beyond margin of valve.

Dimensions (*mm.*)

	Length	Width	Hinge width	L/W
Ventral valve:				
Mont. T1174d...	8.5	8.8	8.3	0.97
Dorsal valves:				
Mont. T1174b...	8.2	10.7	9.6	0.77
Mont. T1174f...	7.5	9.5	7.6	0.79

Syntypes, Mont. T1174a–f.

Horizon and locality.—Upper Cambrian. Dry Creek shale: 44-2, Crowfoot Ridge.

Distinguishing characters.—*Ocnerorthis monticola* is characterized by its stout receding dental plates, concave and strongly apsacline ventral interarea, and stout cupped brachiophores.

Discussion.—This species differs from *O. cooperi* most obviously in the presence of dental plates, and in the orientation of the ventral interarea.

The very apex of the delthyrium in one silicified ventral valve (pl. 37, figs. 7, 10) is filled with callus. The deposit is limited to the apex of the valve, not extending anteriorly as in *O. cooperi*.

Two unsilicified dorsal valves (pl. 37, figs. 6, 8, 13, 15) exhibit a remarkable development of the cardinal process. So far as can be determined, the excessive extension of the structure posteriorly is not a secondary feature.

Only one dorsal valve (pl. 37, fig. 12) shows what may be a part of the muscular

pattern. A pair of elongate scars, slightly divergent anteriorly, border the median ridge about the middle of the valve.

Genus EOORTHIS Walcott, 1908
EOORTHIS REMNICHA (Winchell)
Plate 36, figures 14–23

Orthis remnicha WINCHELL, *1886*, Minnesota Geol. and Nat. History Survey, 14th Ann. Rept., p. 317, pl. 2, fig. 7.

Eoorthis remnicha WALCOTT, *1912*, U. S. Geol. Survey, Mon. 51, p. 786, pl. 91, figs. 1, 1a–s, pl. 92, figs. 2, 2a–d, 3, 3a–e; SCHUCHERT and COOPER, *1932*, Peabody Mus. Nat. History, Mem., vol. 4, pt. 1, pl. 1, fig. 23; Ulrich and Cooper, *1938*, Geol. Soc. America, Special Paper 13, pl. 9E, figs. 16–22.

This is the only species of *Eoorthis* in the collections from Montana. An appreciable variation occurs in the species, especially in the contour of the valves and in the form of the ventral muscular area and cardinal process. None of these variations are sufficiently constant, however, to warrant a varietal assignment to them. Perhaps a statistical treatment of larger collections may lead to a finer definition of the species.

Apparently *Eoorthis remnicha* everywhere occurs associated with species of *Billingsella*, the *Eoorthis* and *Billingsella* subzones of the upper Mississippi Valley province not being recognized in Montana.

Figured specimens, Mont. T1173a–e, T1175a; Mich. 20800a.

Horizon and locality.—Upper Cambrian. Dry Creek shale: 39-1 (?), Yogo Gulch 44-2, Crowfoot Ridge; 46-3, Nixon Gulch; U.S.N.M. localities 4r, Mount Delano; 151, 152, Bridger Range; 153a, 154, 158, near Hillsdale; 302b (2), 302f, Yellowstone Park; 302n, lower Gallatin Valley. Snowy Range formation; M1-4, Beartooth Butte; M2-1, Republic Mt.

Genus HUENELLA Walcott, 1908
HUENELLA ABNORMIS (Walcott)
Plate 36, figures 1–3

Syntrophia abnormis WALCOTT, *1905*, U. S. Nat. Mus., Proc., vol. 28, p. 289.

Huenella abnormis WALCOTT, *1912*, U. S. Geol. Survey, Mon. 51, p. 805, pl. 103, figs. 2, 2a–m; SCHUCHERT and COOPER, *1932*, Peabody Mus. Nat. History, Mem., vol. 4, pt. 1, text figs. 24a–e, p. 160.

Huenella texana (Walcott). WALCOTT, *1924*, Smithsonian Misc. Coll., vol. 67, no. 9, pl. 120, figs. 4–8; ULRICH and COOPER, *1938*, Geol. Soc. America, Special Paper 13, pl. 41D, figs. 20, 29.

Though Walcott (1912, p. 806) believed that this species and *H. texana* intergraded, he recognized two species, because most of the individuals from Montana differ from those from Texas. The present study substantiates Walcott's conclusion. *H. abnormis* is typified by a sharply and strongly folded dorsal valve in which the fold has three costae, the outer two diverging from the apex, and the middle one being implanted anterior to the apex. This type of valve predominates, but some valves show all gradations from a plicate to a smooth fold. The ventral valve is deeply sulcate, the sulcus of most specimens smooth, and that of a few individuals with as many as four narrow low costae. Except for costae on the fold and sulcus, the valves appear to be smooth, with faint concentric growth lamellae. The typical form of *H. texana* has a lower fold and shallower sulcus than *H. abnormis;* in *H. texana* the fold, sulcus, and adjacent flanks of the valves bear low costae.

Holotype, U.S.N.M. 52462b; paratype, U.S.N.M. 52462e.

Horizon and locality.—Upper Cambrian. Dry Creek shale: 46-3, Nixon Gulch; U.S.N.M. localities *4j, head of Deep Creek* and 302g, Crowfoot Ridge, both in Yellowstone Park; 153, 157, 158, all near Hillsdale.

REFERENCES

BELL, W. C., *1938*, *Prototreta*, a new genus of brachiopod from the Middle Cambrian of Montana: *Michigan Acad. Sci., Papers for 1937*, vol. 23, pp. 403–407.

COOPER, G. A., *1936*, New Cambrian brachiopods from Alaska: *Jour. Paleontology*, vol. 10, pp. 212–214.

DEISS, C. F., *1933*, Paleozoic formations of northwestern Montana: *Montana Bur. Mines and Geology, Mem.*, no. 6.

——, *1936*, Revision of type Cambrian formations and sections of Montana and Yellowstone National Park: *Geol. Soc. America, Bull.*, vol. 47, pp. 1257–1342.

——, *1938*, Cambrian formations and sections in part of Cordilleran Trough: *Geol. Soc. America, Bull.*, vol. 49, pp. 1067–1168.

——, *1939a*, Cambrian stratigraphy and trilobites of northwestern Montana: *Geol. Soc. America, Special Paper 18*.

——, *1939b*, Cambrian formations of southwestern Alberta and southeastern British Columbia: *Geol. Soc. America, Bull.*, vol. 50, pp. 951–1026.

——, *1940*, Lower and Middle Cambrian stratigraphy of southwestern Alberta and southeastern British Columbia: *Geol. Soc. America, Bull.*, vol. 51, pp. 731–794.

DORF, ERLING, *1934*, Stratigraphy and paleontology of a new Devonian formation at Beartooth Butte, Wyoming: *Jour. Geology*, vol. 42, no. 7, pp. 721–726.

——, and LOCHMAN, CHRISTINA, *1940*, Upper Cambrian formations in southern Montana: *Geol. Soc. America, Bull.*, vol. 51, pp. 541–556.

KOZLOWSKI, ROMAN, *1932*, Sur un procédé simple et précis d'effectuer coupes sérielles des fossiles: *Palaeont. Zeitschrift*, vol. 14, no. 4, p. 316.

LOVERING, T. S., *1929*, The New World or Cooke City mining district, Park County, Montana: *U. S. Geol. Survey, Bull.* 811-A.

MEEK, F. B., *1873*, *U. S. Geol. and Geog. Survey Terr., Ann. Rept.* 6 (1872), pp. 463, 479.

ÖPIK, A., *1934*, Über Klitamboniten: *Univ. Tartuensis (Dorpatensis), Acta et Comment.*, A 26, 5, pp. 38–40.

RESSER, CHARLES E., *1938*, Fourth contribution to nomenclature of Cambrian fossils: *Smithsonian Misc. Coll.*, vol. 97, no. 10, p. 10.

——, *1939a*, The Spence shale and its fauna: *Smithsonian Misc. Coll.* vol. 97, no. 12, pp. 4–6.

——, *1939b*, The *Ptarmigania* strata of the northern Wasatch Mountains: *Smithsonian Misc. Coll.*, vol. 98, no. 24, pp. 20–23.

——, and ENDO, RIUJI, *1937*, The Sinian and Cambrian formations and fossils of southern Manchoukuo: *Manchurian Sci. Mus., Bull.* 1, pp. 108–145.

SCHUCHERT, CHARLES, and COOPER, G. A., *1932*, Brachiopod genera of the suborders Orthoidea and Pentameroidea: *Peabody Mus. Nat. History, Mem.*, vol. 4, pt. 1.

——, and LE VENE, C. M., *1929*, *Fossilium Catalogus*, pt. 42, *Brachiopoda*.

SIMPSON, G. G., *1933*, A simplified serial sectioning technique for the study of fossils: *Am. Mus. Nat. History, Novitates*, no. 634.

——, *1938*, An improved apparatus for the serial sectioning of fossils: *Science*, n. s., vol. 88, no. 2286, p. 385.

THOMSON, J. A., *1927*, Brachiopod morphology and genera. Recent and Tertiary: *New Zealand Bd. of Sci. Art, Manual* 7.

ULRICH, E. O., and COOPER, G. A., *1938*, Ozarkian and Canadian Brachiopoda: *Geol. Soc. America, Special Paper 13*.

WALCOTT, C. D., *1897a*, Note on the genus *Lingulepis*: *Am. Jour. Sci.*, ser. 4, vol. 3, pp. 404–405.

——, *1897b*, Cambrian Brachiopoda: Genera *Iphidea* and *Yorkia*, with descriptions of new species of each and of the genus *Acrothele*: *U. S. Nat. Mus., Proc.*, vol. 19, pp. 707–718.

——, *1898*, Cambrian Brachiopoda: *Obolus* and *Lingulella*, with description of new species: *U. S. Nat. Mus., Proc.*, vol. 21, pp. 385–420.

——, *1905*, Cambrian Brachiopoda, with descriptions of new genera and species: *U. S. Nat. Mus., Proc.*, vol. 28, pp. 227–337.

——, *1908a*, Cambrian Brachiopoda; Descriptions of new genera and species; *Smithsonian Misc. Coll.*, vol. 53, no. 3, pp. 53–137.

——, *1908b*, Cambrian sections of the Cordilleran area: *Smithsonian Misc. Coll.*, vol. 53, no. 5, pp. 200–203.

——, *1912*, Cambrian Brachiopoda: *U. S. Geol. Survey, Mon.* 51.

——, *1917a*, The *Albertella* fauna in British Columbia and Montana: *Smithsonian Misc. Coll.*, vol. 67, no. 2, pp. 9–26.

——, *1917b*, Fauna of the Mount Whyte formation: *Smithsonian Misc. Coll.*, vol. 67, no. 3, p. 70.

——, *1924*, Cambrian and Ozarkian Brachiopoda: *Smithsonian Misc. Coll.*, vol. 67, no. 9, pp. 477–527.

SUBMITTED IN MAY, 1939, TO THE FACULTY OF THE DEPARTMENT OF GEOLOGY, UNIVERSITY OF MICHIGAN, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY. MANUSCRIPT RECEIVED BY THE EDITOR SEPTEMBER 14, 1940.

JOURNAL OF PALEONTOLOGY, VOL. 15, NO. 3, PP. 256–277, PLS. 38, 39, 2 TEXT FIGS. MAY, 1941

JURASSIC FOSSILS FROM ARKANSAS, LOUISIANA, AND EASTERN TEXAS

RALPH W. IMLAY
Geological Survey, Washington, D. C.

ABSTRACT—Fossils obtained from the deeply buried sedimentary formations of southern Arkansas, northern Louisiana, and eastern Texas, show that the Cretaceous system is underlain by thousands of feet of Jurassic rocks. Some of the Jurassic fossils are described herein, including 22 species of pelecypods, 10 species of gastropods, two species of phyllopods, several fragments of ammonites and one crinoid columnal. Of these, 12 species are described as new, nine are compared with European species, and two are compared with American species. The fossils indicate that none of the Jurassic formations is as old as the Lias.

EXAMINATION of fossils from drill cores obtained from the deep subsurface rocks of southern Arkansas, northern Louisiana, and eastern Texas has shown the presence of thousands of feet of Lower Cretaceous and Jurassic rocks. Fossils from the Jurassic rocks are the material for the present study. Most of the fossils are from coralline beds in the upper part of the Smackover formation of Columbia and Ouachita counties, Arkansas. Some fossils are from the Buckner formation and from the lower part of the Cotton Valley formation. A few pelecypods were found in the Morehouse formation, but the writer was unable to obtain them for study. The Jurassic megascopic fossils consist mainly of pelecypods, gastropods, corals, and brachiopods but include a few fragments of ammonites, a number of specimens of the phyllopod *Estheria*, and one crinoid columnal. The microfauna of ostracods and Foraminifera is said to be abundant but has not yet been studied. The corals have been sent for study and report to J. W. Wells of Ohio State University, and the brachiopods to G. Arthur Cooper of the United States National Museum. It is hoped that the conclusions drawn from this study will encourage the geologists working in the Gulf Coastal area to search carefully for fossils in all cores obtained from deeply buried formations.

The fossils described herein were obtained from various oil companies of the Arkansas-Louisiana-eastern Texas area during the years of 1938–1940. Among the principal contributors were Roy T. Hazzard of the Gulf Refining Company, Henry J. Morgan of the Atlantic Refining Company, Warren B. Weeks of the Phillips Petroleum Company, M. N. Broughton of the Texas Company, and A. F. Crider, consulting geologist. Merle C. Israelsky permitted the writer to examine a sponge obtained from the Morehouse formation. The writer is further indebted to these men for information concerning the stratigraphy of the beds which contained the fossils.

STRATIGRAPHIC SUMMARY

The Jurassic sediments of the Arkansas-Louisiana-eastern Texas area (fig. 1) are completely overlapped by thick Cretaceous and Tertiary sediments and are known, therefore, only as a result of deep drilling. They range in thickness from about 3000 feet in Arkansas to over 7000 feet in northern Louisiana (fig. 2). This southward increase in thickness is accompanied by a change from nearshore, shallow-water sediments to offshore, shallow-water sediments. The former consists mainly of conglomerates, sandstones, red beds, and reef limestones, and the latter of dark shales, marls, and thin-bedded limestones. Anhydrite and salt were deposited both near the shore and offshore. Deposition occurred on a gently sloping, slowly sinking coastal shelf, which was sinking faster toward the south than toward the north. Most of the sinking occurred south of a hinge line marked at present by a zone of faults that extends eastward across southern Arkansas. Uplifts of land masses north of the hinge line caused southward withdrawals of the Gulf waters from Arkansas at the end of Buckner and Cotton Valley times, but marine deposition apparently continued in northern Louisiana

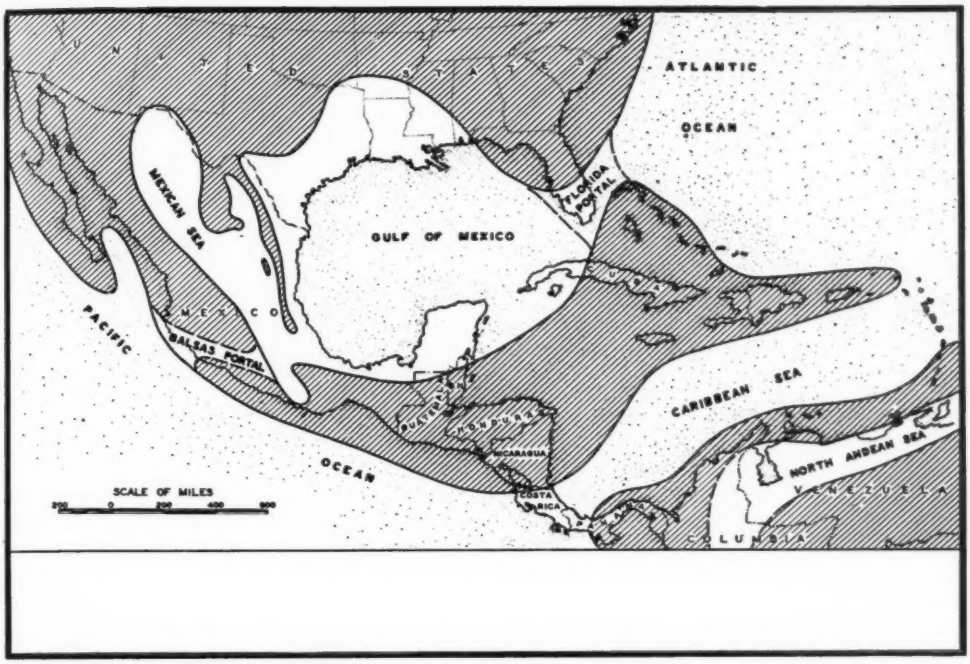


FIG. *1*—Paleogeography of Upper Jurassic time. Modified in part from Burckhardt, Muir, Schuchert, and Imlay.

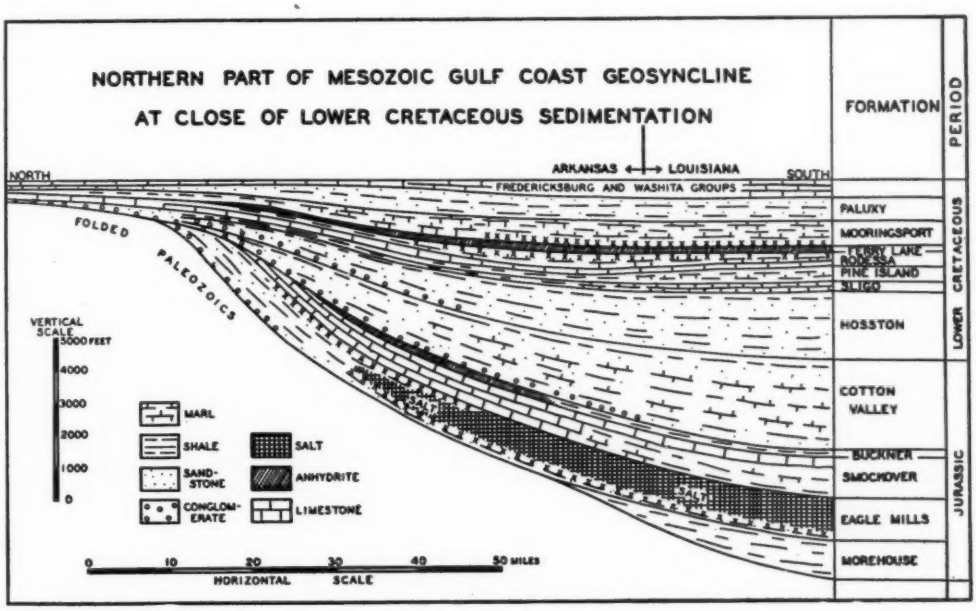


FIG. *2*—Generalized section of southern Arkansas and northern Louisiana. Morehouse formation known only from northeastern Louisiana.

and eastern Texas from about middle Jurassic until the end of the Lower Cretaceous. As the Jurassic formations have been adequately described previously (Weeks, 1938, pp. 956–968; Imlay, 1940a, pp. 7–27) only brief summaries will be presented below.

JURASSIC FORMATIONS IN ARKANSAS, LOUISIANA, AND EASTERN TEXAS

	Feet
Cotton Valley formation: Reddish sandstones and shales in Arkansas grading southward into thicker dark shales, limestones, and sandstones in northern Louisiana. Basal conglomerate in Arkansas and in places in Louisiana. Overlain disconformably in Arkansas by the Hosston formation, of early Cretaceous age	1400–3200
Buckner formation: Red shales, anhydrite, dolomite in Arkansas and northeastern Louisiana, grading southward into thicker dark shales; overlies Smackover formation conformably	100– 495
Smackover formation: In Arkansas consists mainly of an upper member of oolitic to chalky to coralline limestone and a lower member of dense limestone with dark argillaceous bands; passes southward into thicker dark shales and limestones in northwestern Louisiana, and into limestones, sandstones, and dark shales in northeastern Louisiana; overlies Eagle Mills formation conformably	450–1200
Eagle Mills formation: Red beds and anhydrite shoreward, grading into salt and anhydrite basinward along a transition zone which extends east and southeast acrosss southern Arkansas; locally in Arkansas overlies Paleozoic? slate with marked angular unconformity; in northeastern Louisiana rests conformably on the Morehouse formation	1000–1250
Morehouse formation: Dark shales and siltstones; minor amounts of sandy shales, sandy limestones, and red shales; known only from northeastern Louisiana	1190
Total	2950–7310

FOSSILS

The fossils described herein were obtained from 12 wells, of which six are located in southern Arkansas, five in northern Louisiana, and one in eastern Texas. The location of these 12 wells and the upper limits of the Jurassic formations encountered in them are shown in table 1.

The fossils of the Smackover coralline limestone consist almost exclusively of external and internal molds, many of which are excellently preserved and are sufficiently firm for rubber casting. The shells of mollusks and corals in the limestone are represented by cavities or by large crystals of calcite, which more or less fill former cavities. Brachiopod shells are fairly well preserved but are difficult to extract from their matrix without crumbling. The fossils of the shaly beds of the Cotton Valley, Buckner, and Smackover formations are commonly preserved as external molds and casts or as internal molds with fragments of adhering shell material but are not represented by cavities. Specimens of *Pseudomonotis* from sandy beds in the lower part of the Cotton Valley formation retain considerable shell material.

Faunal assemblages.—At least six faunal facies are distinguishable in the Jurassic rocks of the Arkansas-Louisiana-eastern Texas area and may be enumerated as follows:

1, Silty-shaly facies of the Morehouse formation, containing pelecypods and sponges.

2, Calcareous shaly facies of the Smackover formation, containing *Quenstedtia*, *Trapezium?*, and amonites.

3, Coralline-reef facies of the Smackover formation, containing numerous species of the Parallelodontidae, Astartidae, Procerithidae, and Nerineidae. Likewise some representatives of Mytilidae, Trigoniidae, Pectinidae, Corbidae, and Corbulidae. Also many colonial and simple corals, some brachiopods, but no ammonites.

4, Sandy facies of the Cotton Valley formation, with *Pseudomonotis* and *Placunopsis*.

5, Calcareous shaly to silty marine facies of the Cotton Valley formation, with *Ostrea*, *Exogyra*, *Astarte*, *Leda*, *Tancredia*, *Protocardia*, *Quenstedtia?* Also Foraminifera and ostracods.

6, Silty-shaly (red to black) brackish- or fresh-water facies of the Cotton Valley and Buckner formations, with *Cyrena?*, *Volsella?*, *Planorbis*, *Estheria*, and cyprid ostracods.

Analysis of faunas.—The fossils of the

TABLE 1. WELLS FROM WHICH JURASSIC FOSSILS HAVE BEEN OBTAINED

Company	Well	Location	County or Parish, and State	Elevation D.F.	Top of Cotton Valley	Top of Buckner	Top of Smackover	Top of Eagle Mills	Top of Morehouse
Texas	T. C. Adams Estate No. C-1	2450 ft. S., 1850 ft. W. of NW cor. Isa Hatcher Survey well.	Panola, Tex.	287	7785±	Absent?	9920±	11,060	
Union Producing	Tensas Delta No. A-1	1584 ft. S., 1894 ft. W. of NE cor. SE¼ sec. 8, T.22 N., R.4 E.	Morehouse, La.	71	4269	7109	7230	8114	9285
W. J. Furlong, Jr. (H. E. Rondeau-eta)	E. M. Clark No. 1	876 ft. N., 639 ft. W. of SE cor. SE¼NE¼ sec. 10, T.20 N., R.7 E.	Morehouse, La.	102	3125	5840	6200		
Standard Oil of Louisiana	Joe Modisette Frost Lumber Ind. No. 1	660 ft. SW of NE cor. SW¼ sec. 14, T.21 N., R.1 E.	Union, La.	188	6160	9335	9548		
Phillips Petroleum	J. T. Arnold No. 1	660 ft. N., 330 ft. E. of SW¼NE¼ SW¼ sec. 27, T.15 S., R.15 W.	Ouachita, Ark.	207	3380	None	4911	5610	
Gulf Refining	Goodpine No. 1	596 ft. W., 629 ft. N. of SE cor. SW¼ sec. 25, T.14 N., R.8 W.	Bienville, La.	157	9658(?)				
Fohs oil	Craig No. 1	Center of SE¼NE¼ sec. 5, T.18 S., R.14 W.	Union, Ark.	251	4584	6748	6831		
Magnolia Petroleum	Sexton Unit No. 1	15 ft. N., 15 ft. E. of SW cor. NW¼SE¼ sec. 32, T.23 N., R.9 W.	Webster, La.	225	7485	9432	9872		
Atlantic Refining	Levi Garrett No. A-1	Center of NW¼SW¼ sec. 13, T.17 S., R.20 W.	Columbia, Ark.	363	5375	7428	7519		
Atlantic Refining	Levi Garrett No. C-1	Center of SW¼SE¼ sec. 13, T.17 S., R.20 W.	Columbia, Ark.	334	5348	7332	7403		
Atlantic Refining	Spain No. 1	100 ft. W of center of SW¼SW¼ sec. 18, T.17 S., R.19 W.	Columbia, Ark.	322	5302	7374	7471		
Atlantic Refining	Spain No. 2	Center of SE¼SW¼ sec. 19, T.17 S., R.19 W.	Columbia, Ark.	307	5287	7381	7497		

TABLE 2. DISTRIBUTION OF JURASSIC FOSSILS OF ARKANSAS, LOUISIANA, AND EAST TEXAS

Species	Well	Depth	Formation	Location		
				Twp.	k.	Sec. State
Pentacrinus? sp.	Fohs-Craig No. 1	6848–56	Smackover	18 S.,	14 W.,	5, Ark.
Nuculana sp.	Texas Co.-Adams No. C-1	8935–39	Cotton Valley	Panola Co., Texas		
Grammatodon? sp.	Atlantic-Spain No. 1	7566–67	Smackover	17 S.,	19 W.,	18, Ark.
Parallelodon? sp.	Atlantic-Garrett No. C-1.	7476½	Smackover	17 S.,	20 W.,	13, Ark.
Parallelodon? sp.	Atlantic-Spain No. 2	7495	Smackover	17 S.,	19 W.,	19, Ark.
Placunopsis sp.	Standard-Frost No. 1	8574½–76	Cotton Valley	21 N.,	1 E.,	14, La.
Mytilus (Arcomytilus?) sp.	Phillips-Arnold No. 1	4956–71	Smackover	15 S.,	15 W.,	27, Ark.
Exogyra spp.	Various wells	various	Cotton Valley	Louisiana		
Gryphaea spp.	Various wells	various	Cotton Valley	Louisiana		
Cyrena? sp.	Furlong-Clark No. 1	5255–56	Cotton Valley	20 N.,	7 E.,	10, La.
Trigonia spp.	Phillips-Arnold No. 1	4961–76	Smackover	15 S.,	15 W.,	27, Ark.
Chlamys sp.	Atlantic-Spain No. 1	7591–92	Smackover	17 S.,	19 W.,	18, Ark.
Pseudomonotis louisianensis Imlay	Magnolia-Pardee No. C-1.	9470–9790	Cotton Valley	23 N.,	11 W.,	17, La.
Pseudomonotis louisianensis Imlay	Magnolia-Sexton No. 1	9417	Cotton Valley	23 N.,	9 W.,	32, La.
Astarte aff. *fimbriata* Walton	Phillips-Arnold No. 1	4961–76	Smackover	15 S.,	15 W.,	27, Ark.
Astarte aff. *fimbriata* Walton	Atlantic-Garrett No. C-1.	7476½	Smackover	17 S.,	20 W.,	13, Ark.
Astarte cf. *breviacola* Cragin	Texas-Adams No. C-1	8935–9010	Cotton Valley	Panola Co., Texas		
Astarte smackoverensis Imlay	Phillips-Arnold No. 1	4966–71	Smackover	15 S.,	15 W.,	27, Ark.
Astarte (Coelastarte) hazzardi Imlay	Atlantic-Garrett No. A-1.	7619–20	Smackover	17 S.,	20 W.,	13, Ark.
Astarte (Coelastarte) magnoliana Imlay	Atlantic-Spain No. 1	7565–66	Smackover	17 S.,	19 W.,	18, Ark.
Astarte (Coelastarte) n. sp. ind.	Atlantic-Spain No. 1	7593–94	Smackover	17 S.,	19 W.,	18, Ark.
Opis (Coelopis) americana Imlay	Atlantic-Spain No. 1	7565–66	Smackover	17 S.,	19 W.,	18, Ark.
Isocyprina? sp.	Atlantic-Spain No. 1	7595–96	Smackover	17 S.,	19 W.,	18, Ark.
Isocyprina? sp.	Atlantic-Spain No. 2	7580–92	Smackover	17 S.,	19 W.,	19, Ark.
Trapezium? subtrigonum Imlay	Standard-Frost No. 1	8791½–8793½	Smackover	21 N.,	1 E.,	14, La.
Corbis? sp.	Atlantic-Spain No. 2	7495	Smackover	17 S.,	19 W.,	19, Ark.
Tancredia louisianensis Imlay	Gulf-Goodpine No. 1	9759–70	Cotton Valley	14 N.,	8 W.,	15, La.
Tancredia texana Imlay	Texas-Adams No. C-1	8935–39	Cotton Valley	Panola Co., Texas		
Quenstedtia weeksi Imlay	Standard-Frost No. 1	9779–91	Smackover	21 N.,	1 E.,	14, La.
Quenstedtia? sp.	Gulf-Goodpine No. 1	9759–70	Cotton Valley	14 N.,	8 W.,	15, La.
Protocardia sp.	Texas-Adams No. C-1	8935–39	Cotton Valley	Panola Co., Texas		
Mactromya? sp.	Atlantic-Spain No. 1	7566–67	Smackover	17 S.,	19 W.,	18, Ark.
Corbula sp.	Phillips-Arnold No. 1	4946–56	Smackover	15 S.,	15 W.,	27, Ark.
Neritopsis? sp.	Atlantic-Spain No. 1	7565–66	Smackover	17 S.,	19 W.,	18, Ark.
Xystrella? aff. *papillosa* (Deslongchamps)	Atlantic-Garrett No. C-1.	7476	Smackover	17 S.,	20 W.,	13, Ark.
Xystrella? aff. *papillosa* (Deslongchamps)	Atlantic-Spain No. 1	7566–67	Smackover	17 S.,	19 W.,	18, Ark.
Cryptoptyxis? diversicostata Imlay	Atlantic-Garrett No. C-1.	7476	Smackover	17 S.,	20 W.,	13, Ark.
Cryptoptyxis? formosa Imlay	Atlantic-Spain No. 1	7566–67	Smackover	17 S.,	19 W.,	18, Ark.
Cryptoptyxis? aff. *grimaldii* (Guirand and Ogerien)	Atlantic-Garrett No. C-1.	7475½	Smackover	17 S.,	20 W.,	13, Ark.
Gymnocerithium? aff. *josephense* (P. de Loriol)	Atlantic-Spain No. 1	7566–67	Smackover	17 S.,	19 W.,	18, Ark.
Phaneroptyxis? angulata Imlay	Phillips-Arnold No. 1	4946–56	Smackover	15 S.,	15 W.,	27, Ark.
Nerinea aff. *eudesii* Morris and Lycett.	Atlantic-Garrett No. C-1.	7476½	Smackover	17 S.,	20 W.,	13, Ark.
Nerinea cf. *turbatrix* P. de Loriol	Phillips-Arnold No. 1	4946–5077	Smackover	15 S.,	15 W.,	27, Ark.
Nerinea aff. *goodellii* Cragin	Atlantic-Spain No. 1	7566–67	Smackover	17 S.,	19 W.,	18, Ark.
Nerinella? sp.	Atlantic-Spain No. 1	7566–67	Smackover	17 S.,	19 W.,	18, Ark.
Estheria cf. *murchisoniae* Jones	Furlong-Clark No. 1	5240–56	Cotton Valley	20 N.,	7 E.,	10, La.
Estheria cf. *murchisoniae* Jones	Furlong-Clark No. 1	5903–04	Buckner	20 N.,	7 E.,	10, La.
Estheria cf. *forbesii* Jones	Furlong-Clark No. 1	5903–04	Buckner	20 N.,	7 E.,	10, La.
Ammonite fragments	Texas-Adams No. C-1	10,545–50	Smackover	Panola Co., Texas		

Jurassic formations of the Arkansas-Louisiana eastern Texas area consist dominantly of pelecypods, gastropods, corals, and brachiopods. The latter two groups are confined to the reef facies of the Smackover limestone and have not yet been described. Ammonites are represented by a few fragments which might be referred either to perisphinctoids or to berriasellids. One crinoid columnal is referred provisionally to *Pentacrinus*. The phyllopod *Estheria* is represented by several species similar to described Mesozoic species. The pelecypods include about 30 species distributed among 21 genera. Of these, the families Parallelodontidae, Ostreidae, Astartidae, Tancrediidae and Quenstedtiidae are best represented. The gastropods include about 12 species distributed among seven genera and belonging mainly to the families Procerithiidae and Nerineidae. The molluscan genera and species are listed in Table 2. Many of the mollusks are too poorly preserved to merit description.

Correlation.—Evidence for the existence of Jurassic rocks in the Gulf Coastal region of the United States is based mainly on the fossils obtained from the Smackover formation and particularly from its coralline-reef facies. The fossils obtained from the Morehouse, Buckner, and Cotton Valley formations, although strongly suggestive of a

TABLE 3. TENTATIVE CORRELATION OF THE JURASSIC ROCKS OF ARKANSAS, LOUISIANA, AND TEXAS

European Equivalents			English formations (After Arkell, 1933)	Northern Mexico (After Imlay, 1939)	Southern Mexico (Taken from Burckhardt, 1930)	Arkansas, Louisiana and Eastern Texas (Tentative correlation)
Upper Jurassic, or Malm, or White Jura		Tithonian	Purbeck Beds	La Casita Sandstones, shales, marls coal (La Caja marls and limestones off-shore)	Limestones, marls and shales in Vera Cruz, Puebla, Chiapas and Oaxaca. Locally, basal conglomerates and sandstones.	Cotton Valley shales and sandstones Basal conglomerate
		Portlandian	Portland beds			
	Kimmeridgian	Bononian	Kimmeridge Clay			
		Havrian (=Virgulian)				
		Sequanian (=Arstartien)				?
	Oxfordian	Argovian (includes Rauracian at top) (=Lusitanian)	Corallian beds	? La Gloria	?	Buckner red beds and anhydrite Smackover ls., shale, & ss.
		Divesian	Oxford clay	Sandstones & limestones (Zuloaga limestone off-shore)	Salt and red beds in Chiapas, Vera Cruz and Oaxaca.	? Eagle Mills red beds and salt
Middle Jurassic, or Dogger, or Brown Jura		Callovian			? Shales, marls, and limestones in Oaxaca and Guerrero.	? Morehouse shale and siltstone
			Kellaways beds			
		Bathonian	Cornbrash	?	? Marls and limestones	?
			Great Oolite series	Probably not represented		
		Bajocian	Inferior Oolite series		? Shales, sandstones, marls, limestones, and coal beds of Oaxaca and Guerrero.	
		Aalenian				

Jurassic age, would not by themselves constitute proof of an age older than early Lower Cretaceous. Consideration of the fossils as a whole indicates that all these formations are of Jurassic age, but that none is older than Middle Jurassic (see Table 3). The age significance of the fossil content of each formation will now be considered.

The Morehouse formation yielded an internal mold of a sponge from a core taken at the depth of 9304–05 feet from the Union Producing Company's, Tensas Delta No. 1-a well in sec. 8, T. 22 N., R. 4 E., Morehouse Parish, La. This occurrence is about 20 feet below the top of the formation. The sponge probably belongs to the Stauroderm idae, as is indicated by annular constrictions and the plan of its spicules, but apparently does not belong to any described genus. The mold of the sponge bears many nodes, from each of which pass five or six grooves (representing spicules), which join with nearby nodes and form a continuous network. Viewed in certain lights the intersection nodes appear to be arranged roughly in linear series. At the upper end of the

sponge is a bit of another layer of the skeleton, which is marked only by linear ridges. The apparent relationships of this sponge to the Staurodermidae is significant, as that family is exclusively Jurassic and is known mainly from the Upper Jurassic. Some pelecypods, reported to be Mesozoic types, were associated with the sponge in the Morehouse formation but have not been available for examination by the writer.

The Eagle Mills formation has yielded no fossils. Therefore determinations of its age must be based on its position between, and its conformable relations with, the Morehouse and Smackover formations. It does not appear to be much older than the Smackover formation. It is possibly the equivalent of the salt and red beds that underlie Upper Jurassic limestone in southern Mexico (Imlay, 1940a, pp. 12, 13; Burckhardt, 1930, p. 96–97).

The Smackover formation has yielded a fairly large molluscan fauna, some genera of which are exclusively Jurassic, and many species of which are remarkably similar to Jurassic species of Europe. Suggestive but less positive evidence consists of some ammonite fragments of perisphinctoid aspect and one crinoid columnal similar to columnals of *Pentacrinus*. The ranges of some of the molluscan genera are as follows:

Trigonia, Lower Jurassic to Recent.
Astarte, Triassic to Recent.
Coelastarte, Jurassic to lower Upper Cretaceous.
Coelopis, Middle and Upper Jurassic.
Trapezium, Jurassic to Recent.
Tancredia, Upper Triassic to Cretaceous.
Quenstedtia, Bathonian to end of Jurassic.
Protocardia, Jurassic and Cretaceous.
Xystrella, Upper Lias to end of Oxfordian.
Cryptoptyxis, Callovian to Portlandian.
Gymnocerithium, Bathonian to end of Jurassic.
Phaneroptyxis, Bathonian to Cretaceous.
Nerinea, Upper Lias to Cretaceous.

The ranges of the genera show that the fauna of the Smackover formation must be of Middle or Upper Jurassic age. *Coelopis*, *Quenstedtia*, *Xystrella*, *Cryptoptyxis*, and *Gymnocerithium* do not range above the Jurassic. One of the species of *Tancredia* belongs to the group of *T. planata* (Cox, 1929, p. 574), which is not known to range above the Jurassic. Although some of the gastropod genera are questionably identified because of lack of knowledge of their apertures, the writer considers that *Cryptoptyxis*, at least, is certainly present. Such genera as *Coelopis*, *Quenstedtia*, *Gymnocerithium*, and *Phaneroptyxis* show an age not older than Bathonian, or middle Middle Jurassic. Furthermore, *Cryptoptyxis* is not known below the Callovian. The presence of *Xystrella*, if correctly identified, suggests an age not younger than Argovian. Further age evi-

TABLE 4. SIMILAR JURASSIC SPECIES IN GULF COASTAL REGION AND EUROPE

Species from Smackover formation of Arkansas, Louisiana, and eastern Texas	Similar European species	Range of European species
Astarte aff. *A. fimbriata* Walton	*Astarte fimbriata* Walton	Bathonian
Astarte (*Coelastarte*) *hazzardi* Imlay	*Astarte* (*Coelastarte*) *rectangula* Arkell	Argovian
Opia (*Coelopis*) *americana* Imlay	*Opia* (*Coelopis*) *portlandica* P. de Loriol	Portlandian
Quenstedtia weeksi Imlay	*Quenstedtia gibbosa* Hudleston	Argovian
Xystrella aff. *X. papillosa* (Deslongchamps)	*Xystrella papillosa* (Deslongchamps)	Bajocian
Cryptoptyxis? formosa Imlay	"*Pseudocerithium*" *contortum* Brösamlen	Bajocian and Bathonian
Cryptoptyxis? aff. *C. grimaldi* (Guirand and Ogerien)	*Cryptoptyxis grimaldi* (Guirand and Ogerien)	Argovian
Gymnocerithium? aff. G. *josephense* (P. de Loriol)	*Gymnocerithium josephense* (P. de Loriol)	Argovian
Phaneroptyxis? angulata Imlay	*Phaneroptyxis moreana* (d'Orbigny)	Argovian and Sequanian
Nerinea aff. *N. eudesii* Morris and Lycett	*Nerinea eudesii* Morris and Lycett	Bajocian and Bathonian
Nerinea cf. *N. turbatrix* P. de Loriol	*Nerinea turbatrix* P. de Loriol	Lower Kimmeridgian

dence is furnished by the rather striking similarities of some of the species to species in the Middle and Upper Jurassic beds of England, France, Switzerland, and Germany. The most striking of these faunal similarities are shown in table 4.

The ranges of the European species listed on table 4 are based on the works of de Loriol, Cossmann, Arkell, and Dacqué that are available to the writer. They suggest that the age of the Smackover formation is between the Bajocian and Sequanian. The molluscan genera, as noted above, would restrict the age possibilities to the Oxfordian (i.e., Callovian to Argovian). A closer correlation is not justified by the evidence. One fact indicating an age not younger than Argovian is that the Smackover formation does not contain a single species in common with the late Upper Jurassic (Kimmeridgian, Portlandian, and Tithonian) faunas of western Texas and northern Mexico. The Gulf of Mexico and the Mexican sea must have had sufficiently broad connections during Upper Jurassic time that their respective faunas would have had many species in common. Unfortunately the gastropod and pelecypod faunas of Mexico from Jurassic beds older than Kimmeridgian are practically unknown, and, therefore, direct correlation between the Mexican and Gulf Coast areas cannot be made at present. From the evidence at hand, the writer suggests that the Smackover formation is equivalent to at least part of the La Gloria formation of northern Mexico.

The Buckner formation has yielded only ostracods and phyllopods. The former have not been studied. The latter are represented by several species of *Estheria* similar to described Mesozoic species. One of the species is common to both the Buckner formation and the basal part of the Cotton Valley formation. This occurrence suggests that these formations are not separated by much of a time break, even though their contact is disconformable. The gradational relationship of the Buckner formation with the underlying Smackover formation likewise indicates that they are of nearly the same age and suggests that the Buckner formation belongs in the upper Oxfordian or lower Kimmeridgian. Possibly the regressive Buckner formation is the time correlative of the basal sands and gravels of the La Casita formation in northern Mexico (Imlay, 1937, p. 601).

The Cotton Valley formation on the basis of faunal and stratigraphic evidence appears to be of late Upper Jurassic age. *Pseudomonotis louisianensis* Imlay is exceedingly similar to *P. tamaulipana* Imlay (1940b, p. 405, pl. 53, figs. 5–7, 11–15) from the Kimmeridgian of eastern Mexico. One species of *Astarte* is like *A. breviacola* Cragin from the Portlandian and Kimmeridgian of the Malone Mountains of western Texas. *Tancredia louisianensis* Imlay belongs to the group of *T. axiniformis* (Cox, 1929, p. 573), which ranges into the Lower Cretaceous but is rare above the Jurassic. More convincing evidence of a Jurassic age is furnished by *Tancredia texana* Imlay, which evidently belongs to the group of *Tancredia planata* (Cox, 1929, p. 574), whose known range is Bathonian to Portlandian. Other lines of evidence suggest a Jurassic age for the Cotton Valley formation. Commercial paleontologists who have examined the microfossils state that their affinities are Jurassic rather than Cretaceous. The occurrence of species of *Estheria* common to both the Cotton Valley and Buckner formations suggests they are not of greatly different age. A late Upper Jurassic age for the Cotton Valley formation is strongly suggested by its position a few hundred feet above the Smackover formation, which, according to evidence already presented, is probably not younger than Oxfordian. The overlying Hosston and Sligo formations, which underlie the Pine Island formation of upper Aptian age, attain a combined thickness of over 2500 feet in northern Louisiana and probably account for Neocomian and lower Aptian time. The disconformity at the base of the Hosston formation appears to mark the Jurassic-Cretaceous boundary. This point may be settled by studies now in progress dealing with the microfossils.

SYSTEMATIC DESCRIPTIONS

Genus PENTACRINUS Blumenbach, 1804

PENTACRINUS? sp.

Plate 38, figure 32

One crinoid columnal was obtained from the Smackover limestone at a depth of 6848–56 feet, in the Fohs Oil Company's Craig No. 1 well in sec. 5, T. 18 S., R. 14 W.,

Union County, Arkansas. The shape of this columnal greatly resembles columnals of *Pentacrinus*, but identification cannot be made as no surface markings are preserved.

Figured specimen.—No. 21532, Museum of Paleontology, University of Michigan.

Genus NUCULANA H. Link, 1807
NUCULANA sp.
Plate 38, figure 34

One species, represented by two external casts and their counterpart molds, is not sufficiently preserved to allow comparison with other Mesozoic species. Shell moderately elongate, fairly convex anteriorly and beneath beaks, posterior extremity compressed and rostrate. Dorsal margins diverging from the beak at an angle of about 135°; posterodorsal margin slightly concave; anterior margin meeting anterodorsal margin at nearly a right angle, rounding evenly into ventral margin; ventral margin broadly

---

EXPLANATION OF PLATE 38

FIGS. *1–3—Grammatodon?* sp. *1*, Dorsal view of U.M. 21374, ×2. *2, 3*, Internal mold of same specimen. Smackover limestone, Atlantic-Spain no. 1 well, Arkansas. (p. 265)

4—Parallelodon? sp. U.M. 21354, ×2, Smackover limestone, Atlantic-Spain no. 2 well, Arkansas (p. 266)

5, 6—Trigonia spp. *5*, U.M. 21346, ×1.*6*, U.M. 16992, ×2. Smackover limestone, Phillips-Arnold no 1 well, Arkansas. (p. 267)

7, 8—Astarte cf. *A. breviacola* Cragin. *7*, U.M. 21359, ×2. *8*, U.M. 21362, ×2. Cotton Valley formation, Texas-Adams Est. no. C-1 well, Texas. (p. 268)

9—Astarte smackoverensis Imlay, n. sp. Holotype, U.M. 17692, ×1. Smackover limestone, Phillips-Arnold no. 1 well, Arkansas. (p. 268)

10—Parallelodon? sp. U.M. 21369, ×2. Smackover limestone, Atlantic-Garrett no. C-1 well, Arkansas. (p. 266)

11–13—Astarte aff. *A. fimbriata* Walton. *11*, U.M. 16477; *12*, U.M. 16476; *13*, U.M. 21431, ×2. Smackover limestone, Phillips-Arnold no. 1 well, Arkansas (p. 268)

14–17—Opis (*Coelopis*) *americana* Imlay, n. sp. Anterior, lateral, internal, and posterior views of holotype, U.M. 21375, ×3. Smackover limestone, Atlantic-Spain no. 1 well, Arkansas. (p. 270)

18, 24, 25—Quenstedtia weeksi Imlay, n. sp. *18*, paratype 21405, has defective dorsal margins. *24*, Paratype 21358. *25*, Holotype, 21404. All ×1. Smackover shale, Standard-Frost no. 1 well, Louisiana. (p. 272)

19–23—Pseudomonotis louisianensis Imlay, n. sp. *19, 21*, Holotype, U.M. 21392, left valve, ×1 and ×2. *20*, Paratype U.M. 21393, left valve, ×1. *22*, Paratype U.M. 21395, left valve, ×1. *23*, Paratype U.M. 21391, right valve, ×1. Cotton Valley formation, Magnolia-Pardee no. C-1 well, Louisiana. (p. 267)

26—Quenstedtia? sp. U.M. 21388, ×2. Cotton Valley formation, Gulf-Goodpine no. 1 well, Louisiana. (p. 272)

27, 28—Cyrena? sp. *27*, U.M. 21409, ×1. *28*, U.M. 21408, ×1. Cotton Valley formation, Furlong-Clark no. 1 well, Louisiana. (p. 266)

29—Corbis? sp. U.M. 21355, ×1. Smackover limestone, Atlantic-Spain no. 2 well, Arkansas. (p. 271)

30—Tancredia louisianensis Imlay, n. sp. Holotype, U.M. 21387, ×1. Cotton Valley formation, Gulf-Goodpine no. 1 well, Louisiana. (p. 271)

31—Tancredia texana Imlay, n. sp. Holotype, U.M. 21360, ×1. Cotton Valley formation, Texas-Adams Est. no. C-1 well, Texas. (p. 271)

32—Pentacrinus? sp. U.M. 21532, ×3. Smackover limestone, Fohs-Craig no. 1 well, Arkansas. (p. 263)

33—Mytilus (*Arcomytilus?*) sp. U.M. 17201, ×3. Smackover limestone, Phillips-Arnold no. 1 well, Arkansas. (p. 266)

34—Nuculana sp. U.M. 21361, ×1. Cotton Valley formation, Texas-Adams Est. no. C-1 well, Texas. (p. 264)

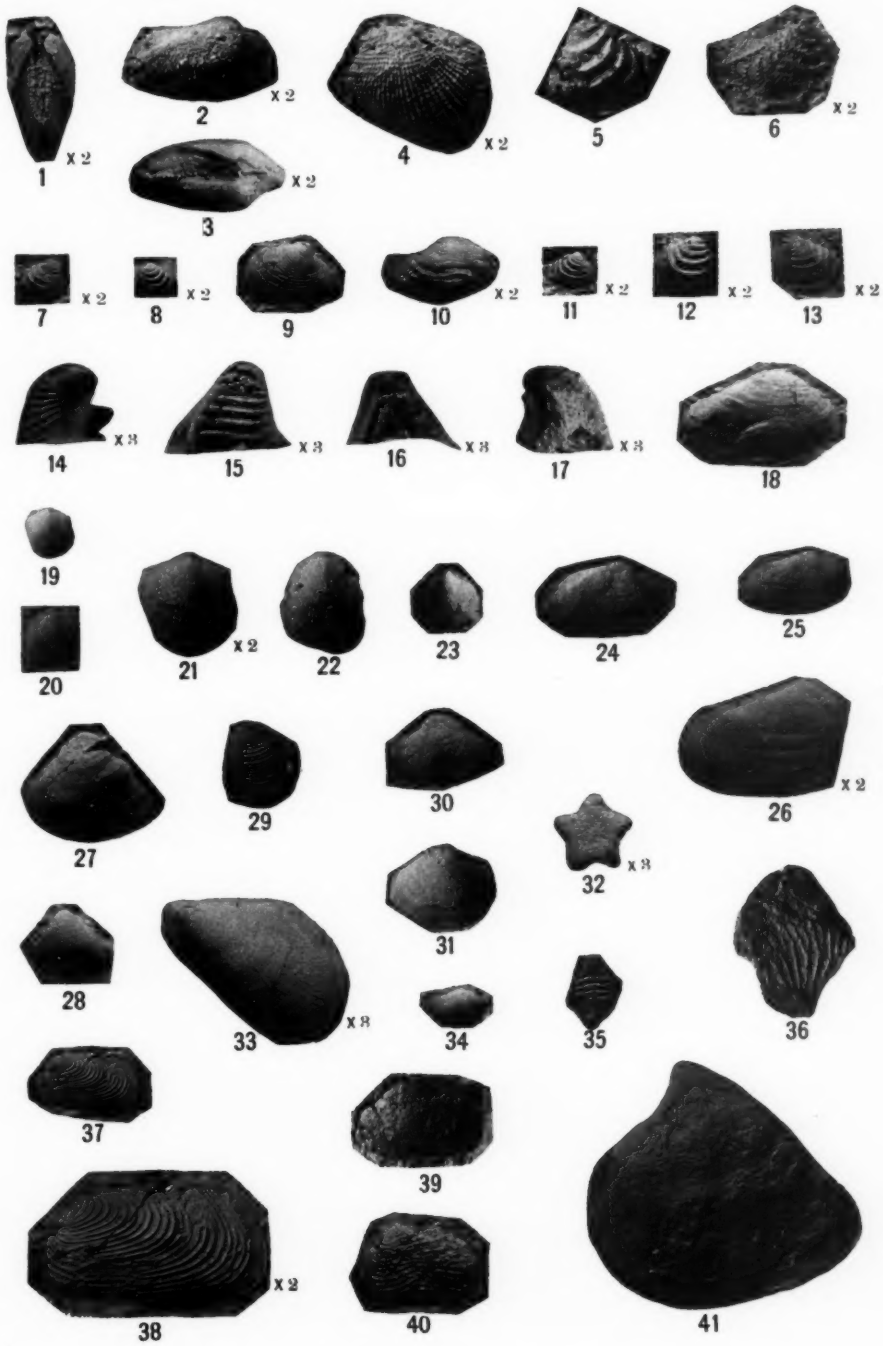
35, 36—Ammonite fragments. *35*, U.M. 21531 ×1. showing ventral groove. *36*, U.M. 21530, ×1. Smackover shale, Texas-Adams Est. no. C-1 well, Texas. (p. 276)

37, 38—Astarte (*Coelastarte*) *hazzardi* Imlay, n.sp. Holotype U.M. 21389, ×1 and ×2. Smackover limestone, Atlantic-Garrett no. C-1 well, Arkansas. (p. 269)

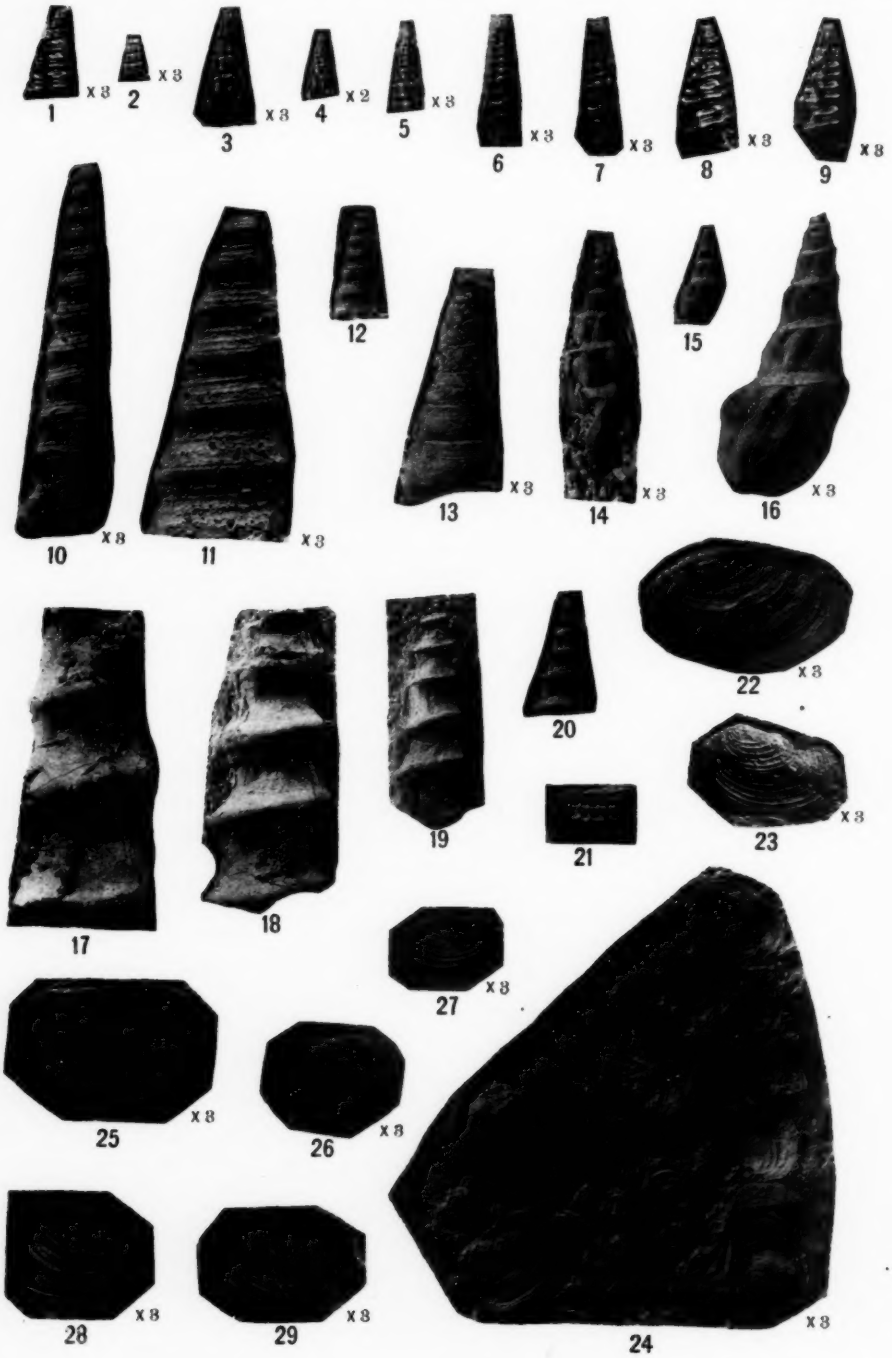
39, 40—Astarte (*Coelastarte*) *magnoliana* Imlay, n.sp. Internal mold and rubber cast of external mold of holotype, U.M. 21373, ×1. Smackover limestone, Atlantic-Spain no. 1 well, Arkansas. (p. 269)

41—Trapezium? subtrigonum Imlay, n. sp. Holotype, U.M. 21397, ×1. Cotton Valley formation, Standard-Frost no. 1 well, Louisiana. (p. 270)

1, 4–6, 9, 10, 14–18, 27, 29, 33, 37, 38, and *40* from rubber casts of external molds.



Imlay, Jurassic Fossils



Imlay, Jurassic Fossils

rounded, passing obliquely upward to the sharply rounded posterior extremity. Beaks projecting above hinge line, apparently orthogyrate, situated about three-eighths the length of the shell from the anterior extremity. Surface ornamented with a few fine concentric lines.

Specimen.—No. 21361, Museum of Paleontology, University of Michigan.

Occurrence.—Cotton Valley formation, The Texas Company's T. C. Adams No. C-1 well at depths of 8935–39 feet, Panola County, Texas.

Genus GRAMMATODON Meek and Hayden, 1860

GRAMMATODON? sp.
Plate 38, figures 1–3

The species is represented by the external and internal molds of one specimen. The external mold shows the dorsal and part of the lateral ornamentation of the shell. Shell small, subquadrangular in outline, equivalve, inequilateral. Dorsal margin straight, making an angle of about 120° with the nearly straight posterior margin; anterior margin regularly rounded; ventral margin parallel to dorsal margin, rounding evenly into anterior margin, forming an acute angle with the posterior margin. Beaks widely separated, low, broad, strongly incurved, prosogyrate, situated about one-third the length of the shell from the anterior extremity. A low angular ridge extends from the beak posteriorly to the posteroventral extremity. The ridge is acute on the umbonal region but becomes obtusely angular posteriorly. Ligamental area wide, apparently nearly smooth. Ventral margin (judging from internal mold) gaping anteriorly and posteriorly but closed medially. Surface ornamented with fine concentric and radial ribs. The concentric ribs dominate on the shell anterior to the posterior ridge, and the radial ribs dominate posterodorsal to the ridge. Dimensions (approximate): Length, 11 mm.; height, 6.5 mm.; thickness, 5.5 mm.

Remarks.—Assignment of this species to *Grammatodon* rather than to *Parallelodon* is indicated by its posterodorsal ridge, its

---

EXPLANATION OF PLATE 39

FIGS. *1, 2—Cryptoptyxis?* aff. *C. grimaldii* (Guirand and Ogerien). *1*, U.M. 21365, ×3, Atlantic-Garrett no. C-1 well, Arkansas. *2*, U.M. 21378, ×3, Atlantic-Spain no. 1 well, Arkansas. Both specimens from the Smackover limestone. (p. 274)

3–5—Xystrella? aff. *X. papillosa* (Deslongchamps), *3, 4*, U.M. 21372, × 3 and ×2, Atlantic-Spain no. 1 well, Arkansas. *5*, U.M. 21366, ×3, Atlantic-Garrett no. C-1 well, Arkansas. Both specimens from the Smackover limestone. (p. 273)

6, 7—Cryptoptyxis? diversicostata Imlay, n. sp. Holotype, U.M. 21368, ×3; *6* emphasizes axial ribbing, *7* emphasizes spiral ribbing. Smackover limestone, Atlantic-Garrett no. C-1 well, Arkansas. (p. 273)

8, 9—Cryptoptyxis? formosa Imlay, n. sp. Holotype U.M. 21377, ×3; *8* emphasizes spiral ribbing, *9* emphasizes axial ribbing. Smackover limestone, Atlantic-Spain no. 1 well, Arkansas. (p. 273)

10—Nerinea aff. *N. goodellii* Cragin, U.M. 21357, ×3. Smackover limestone, Atlantic-Spain no. 1 well, Arkansas. (p. 275)

11, 12—Nerinea aff. *N. eudesii* Morris and Lycett. U.M. 21371, ×3 and ×1, Smackover limestone, Atlantic-Garrett no. C-1 well, Arkansas. (p. 275)

13—Gymnocerithium? aff *G. josephense* (P. de Loriol). U.M. 21379, ×3. Smackover limestone, Atlantic-Spain no. 1 well, Arkansas. (p. 274)

14–16—Phaneroptyxis? angulata Imlay, n. sp. *14*, Paratype U.M. 21347, ×3. *15, 16*, Holotype, U.M. 21352, ×1 and ×3. Both specimens from Smackover limestone, Phillips-Arnold no. 1 well, Arkansas (p. 274)

17–20—Nerinea cf. *N. turbatrix* P. de Loriol. *17*, U.M. 21349. *18*, U.M. 20441; *19*, U.M. 17691; *20*, U.M. 21350. All specimens ×1. Smackover limestone, Phillips-Arnold no. 1 well, Arkansas. (p. 275)

21—Neritopsis? sp. U.M. 21356, ×1. Smackover limestone, Atlantic-Spain no. 1 well, Arkansas. (p. 272)

22–24—Estheria cf. *E. murchisoniae* Jones. From slab numbered U.M. 21528, ×3. Buckner formation, Furlong-Clark no. 1 well, Louisiana. (p. 276)

25–29—Estheria cf. *E. forbesii* Jones. *25, 27*, From slab numbered U.M. 21529; *26, 28, 29*, from slab numbered U.M. 21528. All specimens ×3. Buckner formation, Furlong-Clark no. 1 well, Louisiana. (p. 276)

1–21 from rubber casts of external molds.

relatively short form, and the lack of an alar prolongation of the posterior end of its hinge line. The ventral gaping of the shell indicated by the internal mold may be more apparent than real. The species bears considerable resemblance in form and ornamentation to *Grammatodon rhomboidalis* (Contejean) as figured by Loriol (1868, p. 621, pl. 11, figs. 18, 18a) but appears to have a more angular ridge and stronger radial ribs. *G. rhomboidalis* ranges from Sequanian to Virgulian according to Arkell (1930, p. 340).

Specimen—No. 21374, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Atlantic Refining Company's Spain No. 1 well at depth of 7566–67 feet, sec. 18, T. 17 S., R. 19 W., Columbia County, Arkansas.

Genus Parallelodon Meek and Worthen, 1866
Parallelodon? spp.
Plate 38, figures 4, 10

Two external molds, representing distinct species, probably belong to the Parallelodontidae but cannot be definitely placed generically at the present time.

The species figured on pl. 38, fig. 4, probably represents the anterior part of a right valve. It is rather compressed, subquadrate in outline, and has a broad, incurved, slightly prosogyrate beak. Its ornamentation consists of strong radial ribs and moderately strong concentric growth lines, whose intersections produced a reticulated appearance. Interspaces are slightly wider than the radial ribs, particularly on the anterodorsal margin. Ribs increase in number by bifurcation in the umbonal region.

The species figured on pl. 38, fig. 10, represents the anterior part of a left valve. It is compressed, elongate-quadrate in outline, and has a broad incurved beak. A broad shallow sinus begins on the umbonal region and occupies the medial part of the shell. Its ornamentation consists of numerous fine, close-set radial ribs, of many very fine concentric ribs, and of a few pronounced growth halts. The radial ribs are coarsest anterodorsally and increase in number by implantation and bifurcation on all parts of the shell. The interspaces are much narrower than the radial ribs in the medial part of shell but become as wide near the anterodorsal margin. This species may be distinguished from the species described above by its more elongate form and finer, less reticulate ribbing. Its preserved part bears some resemblance to *Parallelodon* (*Beushausenia*) *transversum* (Morris and Lycett) (1853, p. 47, pl. 5, fig. 8).

Specimens.—Nos. 21369 and 21354, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, (1) Atlantic Refining Company's Levi Garrett No. C-1 well at depth of 7476½ feet, sec. 13, T. 17 S., R. 20 W., Columbia County, Arkansas; (2) Atlantic Refining Company's Spain No. 2 well at depth of 7495 feet, sec. 19, T. 17 S., R. 19 W., Columbia County, Arkansas.

Genus Mytilus Linnaeus, 1758
Mytilus (Arcomytilus?) sp.
Plate 38, figure 33

One external mold probably represents an immature individual. Shell small, very inequilateral, elongate, sickle-shaped, fairly convex. Hinge line straight and long, three-fifths of the length of the shell. Anterior margin rounded, very small; posterior margin evenly rounded, meeting hinge margin at a wide obtuse angle, rounding rather abruptly into ventral margin, which is long and slightly concave. Beak narrow and terminal. A rounded carina extends from the beak to the posteroventral region and is preceded anteriorly by a feeble sulcus. Surface ornamented by inconspicuous concentric growth lines and by nearly microscopic radiating lines.

Specimen.—No. 17201, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Phillips Petroleum Company's J. T. Arnold No. 1 well at depth of 4966–71 feet, sec. 27, T. 15 S., R. 15 W., Ouachita County, Arkansas.

Genus Cyrena Lamarck, 1818
Cyrena? sp.
Plate 38, figures 27, 28

The species is represented by several molds. Shell moderate in size for genus, subtrigonal in outline, inequilateral, moderately convex. Anterodorsal margin concave, steeply inclined; posterodorsal margin convex in the beak region, nearly straight pos-

teriorly, longer and less steeply inclined than anterodorsal margin; posterior margin short, truncate, rounding abruptly into ventral margin and posterodorsal margin; anterior margin narrowly rounded above, passing evenly below into ventral margin, which is long and fairly convex. Beak low, inclined forward, situated about four-tenths the length of the shell from the anterior extremity. A slight swelling extends from the beak to the posteroventral angle. Surface ornamented with many fine concentric growth lines, which become stronger ventrally. Dimensions of specimen shown on pl. 38, fig. 28: Length, 10.5 mm.; height, 9 mm. (?).

Remarks.—This species bears some resemblance in shape to *Cyrena media* (Sowerby) (1826, p. 51, pl. 527, fig. 2) from the Upper Jurassic of England but is more trigonal in outline and less elongate.

Specimens.—Nos. 21408, 21409, Museum of Paleontology, University of Michigan.

Occurrence.—Cotton Valley formation, Furlong-Clark No. 1 well at depth of 5255–56 feet, sec. 10, T. 20 N., R. 7 E., Morehouse Parish, Louisiana.

Genus TRIGONIA Bruguière, 1789
TRIGONIA spp.
Plate 38, figures 5, 6

The genus is represented by three external molds and one external cast. The form figured on pl. 38, fig. 6, may be described as follows: Shell small, subtrigonal, compressed. Margins not well preserved; dorsal margin concave; anterior and ventral margins broadly rounded. Beak elevated, pointed, curved inward and backward. Area moderate in width; slightly concave; bearing widely spaced fine transverse striations; marked medially by a faint oblique furrow; bounded above and below by tuberculated ridges. Escutcheon not known. Main surface of shell ornamented with widely spaced tuberculate ribs, which are small above but become larger anteriorly. Dorsally they form an acute angle with the ridge limiting the area, but anteriorly they curve strongly forward. The dorsal parts of the first five ribs are bent in sharp angles. The tubercles surmounting the ribs are compressed and produced posteriorly to the bottom of the interspaces.

The form figured on pl. 38, fig. 5, is probably a different species than that just described above, as its area is marked by finer transverse striations and its preareal tubercles are more compressed.

Remarks.—The forms described above bear a general resemblance to *Trigonia proscabra* Cragin (1905, p. 60, pl. 10, figs. 3–6) but their preareal ribs are wider spaced, and their areas are much different. They more closely resemble *T. formosa* Lycett (1872, p. 35, pl. 5, figs. 4–6) but the tubercles on the preareal ribs appear to be more produced posteriorly.

Specimens.—Nos. 16992, 21346, 21353, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Phillips Petroleum Company's J. T. Arnold No. 1 well at depths of 4961–66 and 4971–76 feet, sec. 27, T. 15 S., R. 15 W., Ouachita County, Arkansas.

Genus PSEUDOMONOTIS Beyrich, 1862
PSEUDOMONOTIS LOUISIANENSIS
Imlay, n. sp.
Plate 38, figures 19–23

The species is represented by numerous fragmentary specimens. Shell small, ovate in outline, higher than long, slightly inequilateral, very inequivalve; left valve highly convex, with large beak projecting strongly beyond the hinge line; right valve gently convex, with small beak barely projecting beyond the hinge line. Hinge line a little more than half the length of the shell.

Ornamentation of left valve consists of strong, threadlike, slightly wavy, radial ribs and numerous faint concentric growth lines. Radial ribs increase in number by implantation. Interspaces about 1½ times wider than ribs. Strength of ribbing varies on different specimens. Ornamentation of right valve consists of faint concentric and radial ribs.

Remarks.—This species is very similar to *P. tamaulipana* Imlay (1940b, p. 405 pl. 53) from the Kimmeridgian of eastern Mexico but averages smaller in size and has stronger ribbing and more pronounced beaks.

Type.—Holotype 21392, paratypes 21391, 21393–21395, Museum of Paleontology, University of Michigan.

Occurrence.—Cotton Valley formation, (1) Magnolia Petroleum Company's Pardee

No. C-1 well at depths of 9470–9790 feet, sec. 17, T. 23 N., R. 11 W., Louisiana; (2) Magnolia Petroleum Company's Sexton Unit 1 well at depth of 9417 feet, sec. 32, T. 23 N., R. 9 W., Louisiana.

Genus ASTARTE Sowerby, 1816
ASTARTE aff. A. FIMBRIATA Walton
Plate 38, figures 11–13

This species is represented by four specimens in the University of Michigan collections. Shell small, moderately convex, most inflated above the midheight, subquadrate to subtriangular in outline, very inequilateral. Anterodorsal margin concave; posterodorsal margin long and nearly straight, from 1½ to two times longer than anterodorsal margin, forming a subobtuse angle with posterior margin, which is nearly truncated; ventral margin broadly convex, rounding evenly into anterior and posterior margins. Beaks small, depressed, curved forwards, situated about one-third the length of the shell from the anterior end.

Surface ornamented with seven to 10 sharp, prominent, regularly arranged, concentric ribs, which are steepest on their dorsal slopes. Interspaces broadly rounded. Faint concentric growth lines present. Dimensions of specimen no. 21431: Length, 4.4 mm.; height, 3.7 mm.

Remarks.—The Arkansas specimens are remarkably similar to *Astarte fimbriata* Walton (Lycett, 1863, p. 77, pl. 40, figs. 34, 34a) from the Great Oolite (Middle Jurassic) of England. They average a little smaller than Lycett's types but are as large as the specimens figured by Greppin (1888, p. 101, pl. 7, fig. 10, pl. 10, fig. 16) from the Great Oolite of Switzerland.

Specimens.—Nos. 16476, 16477, 17689, 21431, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, (1) Phillips Petroleum Company—J. T. Arnold No. 1 well at depths of 4961–76 feet, sec. 27, T. 15 S., R. 15 W., Ouachita County, Arkansas; (2) Atlantic Refining Company—Levi Garrett No. C-1 well at depth of 7476½ feet, sec. 13, T. 17 S., R. 20 W., Columbia County Arkansas.

ASTARTE cf. A. BREVIACOLA Cragin
Plate 38, figures 7, 8

The species is represented by about a dozen external molds and casts. Shell very small, moderately convex, most inflated above the midheight, subquadrate to triangular ovate in outline, inequilateral. Anterodorsal margin short and concave; posterodorsal margin long and nearly straight; posterior margin fairly wide and truncated, meeting the posterodorsal margin at almost a right angle, rounding rather abruptly into the ventral margin; anterior margin narrowly rounded; ventral margin long, gently convex, rounding evenly into the anterior margin. Beaks moderately prominent, curved forwards, elevated above hinge line, situated from one-third to two-fifths the length of the shell from the anterior extremity. Surface ornamented with five to seven prominent, rounded, widely spaced, concentric ribs, which are steepest on their dorsal slopes. Interspaces broadly rounded. Faint concentric growth lines present. Approximate dimensions of figured specimen no. 21362: Length, 2.6 mm.; height, 2 mm.

Remarks.—This species is possibly an immature form of *Astarte breviacola* Cragin (1905, p. 64, pl. 11, fig. 4) from the Upper Jurassic of West Texas. It is about one-fifth as large as Cragin's species and appears to have fewer, more widely spaced ribs. *A.* aff. *A. fimbriata* Walton, described herein, is less elongate, and has sharper, more numerous ribs. *A. bulla* Römer as figured by Goldfuss and Münster (1837, p. 191, pl. 134, figs. 10a–c) is very similar in size, shape, and ornamentation but has more central beaks.

Specimens.—Nos. 21359, 21362, Museum of Paleontology, University of Michigan.

Occurrence.—Cotton Valley formation, The Texas Company's T. C. Adams No. C-1 well at depths of 8935–39 and 9006–10 feet, Panola County, Texas.

ASTARTE SMACKOVERENSIS
Imlay, n. sp.
Plate 38, figure 9

The species is represented by one external mold. Shell fairly small, elongate-oval, compressed, most inflated above the midheight, inequilateral. Dorsal margins diverge from beaks at an angle of about 125°. Anterior end shorter and more narrowly rounded than posterior end. Posterodorsal margin nearly straight, a little longer than anterodorsal margin, meeting the posterior margin at a subobtuse angle; anterodorsal margin

gently concave, steeper than posterodorsal margin; anterior margin rather narrowly rounded; posterior margin broadly rounded; ventral margin long and gently convex. Beak low, curved slightly forward, situated about one-third the length of the shell from the anterior extremity. Surface ornamented with about 26 high, narrow concentric ribs, which are strongest in the medial part of the shell and pass toward the margins into fine concentric striae. Length, 13 mm.; height, 9.5 mm.

Remarks.—This species is unusually elongate for an *Astarte*. It possibly belongs in the subgenus *Coelastarte* Boehm (1893, pp. 169, 174) but is not like any of the described species.

Type.—Holotype 17692, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Phillips Petroleum Company's J. T. Arnold No. 1 well at depths of 4966–71 feet, sec. 27, T. 15 S., R. 15 W., Ouachita County, Arkansas.

Subgenus COELASTARTE Boehm, 1893
ASTARTE (COELASTARTE) HAZZARDI Imlay, n. sp.
Plate 38, figures 37, 38

The species is represented by one external mold of a left valve, whose anterior margin is slightly defective. Shell very flat, elongate, rectangular in outline, inequilateral. Posterodorsal margin long and nearly straight; anterior margin short and rounded; posterior margin nearly straight, oblique, meeting the dorsal margin at a subobtuse angle, meeting the ventral margin at a subacute angle; ventral margin nearly straight, parallel to hinge margin. Beak small, compressed, not elevated above hinge line, situated about one-eighth the length of the shell from the anterior end. A flat oblique ridge trends from the beak to the posteroventral angle. A weaker ridge trends from the umbo to the anteroventral margin. Between the ridges is a broad, faint depression.

Surface ornamented by about 29 narrowly rounded concentric ribs, which are narrowest and highest where they cross the oblique ridges. Interspaces broadly rounded to nearly flat; in most places from two to three times wider than ribs. Microscopic growth lines cover the entire surface. Length 16 mm.; height, 9 mm.

Remarks.—This species bears a general resemblance to *Coelastarte rectangula* Arkell (1934, p. 248, pl. 33, fig. 16) from the Upper Jurassic of England but has sharper ribbing, a less developed medial depression, and a more anteriorly situated beak. It resembles *C. rzehaki* Boehm (1883, p. 558, pl. 62, fig. 33) even closer in the position of its beak and the character of its ribbing, but it is relatively more elongate and has a straighter dorsal margin. *A. rathieri* P. de Loriol (1893, p. 107, pl. 8, figs. 2, 3) from the upper Oxfordian of France has a similar shape but coarser ribbing. *A. reginae* P. de Loriol (1893, p. 108, pl. 8, figs. 4–6) has similar ribbing but a less rectangular shape. *A.* cf. *A. cotteausia* d'Orbigny in Dietrich (1933, p. 42, pl. 4, fig. 61) is less elongate and less rectangular in outline. This species is named in honor of Roy T. Hazzard, geologist of the Gulf Refining Company, at Shreveport, Louisiana.

Type.—Holotype 21389, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Atlantic Refining Company's L. Garrett No. A-1 well at depth of 7619–20 feet, sec. 13, T. 17 S., R. 20 W., Columbia Co. Arkansas.

ASTARTE (COELASTARTE) MAGNOLIANA Imlay, n. sp.
Plate 38, figures 39, 40

The species is represented by the external and internal molds of a left valve. Shell fairly flat, elongate, subrectangular in outline, inequilateral. Posterodorsal margin long and nearly straight; anterodorsal margin short and concave; anterior margin nearly vertical, about two-thirds as long as the posterior margin, rounding rather abruptly into dorsal and ventral margins; posterior margin nearly straight, oblique, meeting the dorsal margin at a subobtuse angle and the ventral margin at a subacute angle; ventral margin long, roughly parallel to hinge margin, concave near middle. Beak fairly small, compressed, curved inward and forward, barely elevated above hinge line, situated about two-fifths the length of the shell from the anterior end. A moderately prominent oblique ridge trends from the beak to the posteroventral angle. The ridge is paralleled anteriorly by a broad, shallow depression. Surface ornamented by about 20 elevated, narrowly rounded concentric ribs, which recurve abruptly on the oblique ridge and meet the dorsal margin at about a

right angle. Interspaces broadly rounded and about twice as wide as ribs. Length, 16 mm.; height, 11 mm.

Remarks.—This species differs from *Astarte* (*Coelastarte*) *hazzardi* Imlay by being less elongate, less flattened, by having a more pronounced oblique ridge and sinus, and by having fewer ribs. It greatly resembles *Astarte* (*Coelastarte*) *möschi* Rollier (1912, p. 111, pl. 8, figs. 6, 6a) which occurs in the Lower Jurassic (?) of Switzerland but is much smaller and less elongate posteriorly.

Type.—Holotype 21373, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Atlantic Refining Company's Spain No. 1 well at depth of 7565–66 feet, sec. 18, T. 17 S., R. 19 W., Columbia County, Arkansas.

Genus OPIS Defrance, 1825
Subgenus COELOPIS Munier-Chalmas, 1887
OPIS (COELOPIS) AMERICANA
Imlay, n. sp.
Plate 38, figures 14–17

The species is represented by the external and internal molds of a single right valve. Shell small, thick, subquadrate in outline, much higher than long, inequilateral, fairly inflated, with flattened sides. Anterior margin nearly straight, inclined more steeply than posterior margin. Posteroventral angle acute; anteroventral angle subacute. Beaks large, prominent, greatly incurved, inclined forward, terminating acutely. A prominent narrow ridge extends from the beak to the posteroventral angle. It is paralleled on both sides by shallow depressions. A low rounded swelling extends from the beak to the anteroventral angle. The posterior ridge and the anterior swelling divide the shell in such a manner that the medial surface between them lies about at right angles to the anterior and posterior surfaces. Lunule fairly large and deep, heart-shaped, smooth, sharply differentiated. Escutcheon long and elliptical. A single prominent cardinal tooth is bounded posteriorly by a deep cavity. Surface ornamented with coarse, prominent, regularly spaced concentric ribs, which become fine near the anterior margin and are lacking on the surface posterior to the oblique posterior ridge. Interspaces a little wider than ribs. Length (incomplete) 5 mm.; height (incomplete) 3.5 mm.

Remarks.—This species has a form somewhat similar to *Opis cardissoides* Goldfuss and Münster (1837, p. 186, pl. 133, figs. 10a–e), but its ribbing is much different. It bears a greater resemblance to *O. moreana* Buvignier as figured by Loriol (1891, p. 250, pl. 27, figs. 8a, 8b) but is more coarsely ribbed, has a smaller lunule, and is less elongate. It compares closely in size, form, and ornamentation with *O. portlandica* P. de Loriol (1868, p. 592, pl. 13, figs. 5, 5a) but appears to be a little less elongate and its posterior ridge is less oblique.

Type.—Holotype 21375, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Atlantic Refining Company's Spain No. 1 well at depth of 7565–66 feet, sec. 18, T. 17 S., R. 19 W., Columbia County, Arkansas.

Genus TRAPEZIUM Megerle v. Mühlfeldt, 1811
TRAPEZIUM? SUBTRIGONUM
Imlay, n. sp.
Plate 38, figure 41

The species is represented by one specimen whose anterior extremity is defective. Shell fairly large for genus, not very ventricose, subtrigonal in outline, inequilateral. Anterodorsal and posterodorsal margins diverge from the apex at an angle of about 90°, the former very concave, the latter gently convex. Anterior margin rather narrowly rounded; ventral margin long, convex, inclined upward toward anterior margin; posterior margin long, continuous with dorsal margin, rounding rather abruptly at lower extremity into ventral margin. Beaks prominent, incurved, strongly prosogyrate, situated in front of the midlength. A rounded, umbonal ridge extends from the beak toward the lower posterior extremity. The ridge is paralleled anteriorly by a broad, shallow depression, which originates low on the umbonal slope. Lunule apparently deep. Surface marked with weak concentric lines of growth. No radial marking present. Length, 36 mm.; height, 33 mm.

Remarks.—This species does not closely resemble any of the species of "*Cypricardia*," "*Pseudotrapezium*," or *Trapezium* of which descriptions and illustrations are available

to the writer. It is somewhat like *Cypricardia bathonica* d'Orbigny as figured by Morris and Lycett (1853, p. 75, pl. 7, figs. 8a–c) but is less elongate posteriorly. Its shape in lateral view is like that of the Bajocian form, *Cypricardia triangularis* Mérian, as figured by Greppin (1899, p. 77, pl. 8, figs. 1, 1a) but lacks the pronounced anterior ridge possessed by the latter.

Type.—Holotype 21397, Museum of Paleontology, University of Michigan.

Occurrence.—Cotton Valley formation, Standard Oil Company of Louisiana—Joe Modisette Frost Lumber Ind. No. 1 well at depth of 8791½–8793½, sec. 14, T. 21 N., R. 1 E., Union Parish, Louisiana.

Genus CORBIS Cuvier, 1817
CORBIS? sp.
Plate 38, figure 29

One fragment of an external mold is suggestive of the large, rounded anterior end of *Corbis*. Its form is inflated. Its beak is broad, prominent, and apparently orthogyrate. Its surface is ornamented with 28 to 30 high, narrowly rounded, concentric ribs, which are separated by much wider, nearly flat interspaces. No radial markings visible.

The form and ornamentation of the fragmentary Arkansas species bear a suggestive resemblance to *Corbis lajoyei* var. *cingenda* Morris and Lycett (1853, p. 70, pl. 7, fig. 11) from the Great Oolite of England.

Specimen.—No. 21355, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Atlantic Refining Company's Spain No. 2 well at depth of 7495 feet, sec. 19, T. 17 S., R. 19 W., Columbia County, Arkansas.

Genus TANCREDIA Lycett, 1850
TANCREDIA LOUISIANENSIS
Imlay, n. sp.
Plate 38, figure 30

The species is represented by one external cast. Shell small for genus, compressed, elongate, subtrigonal, very inequilateral. Anterior end a little longer than the posterior, subacutely rounded at junction with ventral margin. Anterodorsal margin long, steep, nearly straight; posterior margin rounded; ventral margin gently convex, rounding evenly into posterior margin. Beaks low, slightly posterior to the midlength. Posterior end gaping, as shown by its being deflected outward. Surface ornamented with faint concentric growth lines. Length, 14 mm.; height, 10 (?) mm.

Remarks.—This species probably belongs to the group of *Tancredia axiniformis* (Cox, 1929, p. 573) although the posterior slope is not distinctly ridged as is characteristic of the group. Aside from this difference, the Louisiana species is similar to *T. brevis* Morris and Lycett (1855, p. 92, pl. 13, fig. 8) from the Bathonian of England.

Holotype.—21387, Museum of Paleontology, University of Michigan.

Occurrence.—Cotton Valley formation, Gulf Refining Company's Goodpine No. 1 well, at depth of 9759–70 feet, sec. 15, T. 14 N., R. 8 W., Bienville Parish, Louisiana.

TANCREDIA TEXANA Imlay, n. sp.
Plate 38, figure 31

The species is represented by two external casts and an external mold corresponding with one of the casts. Shell small for genus, fairly compressed, ovate-trigonal, inequilateral. Anterior end longer than the posterior. Anterodorsal margin longer and more steeply inclined than posterodorsal; anterior margin short, nearly vertical, meeting adjoining margins at subobtuse angles; posterior margin broadly rounded; ventral margin gently convex. Beaks fairly low, slightly posterior to the midlength. Posterior end apparently gaping. Surface ornamented with faint concentric growth lines and several growth halts. Dimensions of holotype: Length, 14 mm.; height, 10.5 (?) mm.

Remarks.—This species may be distinguished from *Tancredia louisianensis* Imlay by its less narrowly rounded anterior and by its less compressed form. Its contour is similar to *T. subplanata* Arkell (1934, p. 294, pl. 37, figs. 12, 12a) but it is much less inflated. *T. planata* Morris and Lycett (1855, p. 94, pl. 13, figs. 10a, b) from the Bathonian of England appears to be thicker and more elongate. *T. astarteformis* Cox (1929, p. 575 pl. 13, figs. 1, 2) from the Kimmeridgian of England has sharper beaks. The Louisiana species evidently belongs to the group of *Tancredia planata* (Cox, 1929, p. 574), whose known range is Bathonian to Portlandian.

Type.—Holotype 21360, paratype 21363, Museum of Paleontology, University of Michigan.

Occurrence.—Cotton Valley formation, The Texas Company's T. C. Adams Estate No. 1 well at depth of 8935–39 feet, Panola County, Texas.

Genus QUENSTEDTIA Morris and Lycett, 1854

QUENSTEDTIA WEEKSI Imlay, n. sp.
Plate 38, figures 18, 24, 25

This species is represented by two external casts and one external mold. Shell small for genus, compressed, elongate-ovate, very inequilateral. Anterior end shorter and more narrowly rounded than posterior end. Dorsal margin convex, anterodorsal margin much shorter and steeper than posterodorsal; anterior margin narrowly rounded; posterior margin fairly broad, meeting dorsal margin at a subacute angle; ventral margin gently convex. Beaks low, flattened, projecting slightly above the hinge line, about one-third the length of the shell from the anterior end. A broad obtuse ridge trends from the umbo to the posteroventral angle. Surface ornamented with faint growth lines, which are most pronounced near the ventral and posterior margins. Dimensions of holotype, U. M. 21404: Length, 15 mm.; height, 8 mm. Paratype, U. M. 21358: Length, 18 mm.; height, 9.5 mm.

Remarks.—The Louisiana species resembles *Q. gibbosa* Hudleston (Arkell, 1934, p. 299, pl. 40, figs. 1–3) in the contour of its shell but is much smaller, less inflated, and has more anteriorly situated beaks. *Q. laevigata* (Phillips) (Arkell, 1934, p. 296, pl. 40, figs. 4, 5) is less elevated and has a more quadrate contour. This species is named in honor of Warren B. Weeks, geologist for the Phillips Petroleum Company, at Shreveport, Louisiana.

Type.—Holotype 21404, paratypes 21358, 21405, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover shaly beds, Standard Oil Company of Louisiana—Joe Modisette Frost Lumber Ind. No. 1 well at depth of 9779–91 feet, sec. 14, T. 21 N., R. 1 E., Union Parish, Louisiana.

QUENSTEDTIA? sp.
Plate 38, figure 26

One fragment of an external mold represents the posterior and medial parts of a species probably belonging to *Quenstedtia*. Form elongate, compressed; posterior end long and subquadrate; beak low, projecting slightly above the hinge line; surface ornamented with fine, irregularly spaced growth lines.

Specimen.—No. 21388, Museum of Paleontology, University of Michigan.

Occurrence.—Cotton Valley formation, Gulf Refining Company's Goodpine No. 1 well at depth of 9759–70 feet, sec. 15, T. 14 N., R. 8 W., Bienville Parish, Louisiana.

Genus PROTOCARDIA Beyrich, 1845

PROTOCARDIA sp.

One small, poorly preserved external cast represents this genus. Its form is ovate, apparently slightly longer than high, fairly convex, subequilateral. Anterodorsal margin steeper than posterodorsal; other margins evenly rounded. Beaks moderate in size, curved inward, medial. Main part of shell ornamented with numerous flat-topped concentric ribs, which are separated by much narrower slitlike interspaces. Posterior fourth of shell ornamented with flat-topped radial ribs.

Specimen.—No. 21364, Museum of Paleontology, University of Michigan.

Occurrence.—Cotton Valley formation, The Texas Company's T. C. Adams Est. No. C-1 at depth of 8935–39 feet, Panola County, Texas.

Genus NERITOPSIS Sowerby, 1825

NERITOPSIS? sp.
Plate 39, figure 21

One fragment of an external mold shows high, narrow spiral ribs and slightly less prominent vertical ribs, which are tuberculate at their intersection points. Only six rows of spiral ribs are preserved, but the whorl probably had several more. The posterior (?) margin is rather abruptly flattened.

The ornamentation of the Arkansas species is a little like *Neritopsis cottaldina* d'Orbigny (1852, p. 227, pl. 301, figs. 11–13; Loriol, 1887, p. 157, pl. 17, figs. 1–5) from

the Upper Jurassic of Europe, but the latter species at a comparable size bears spiral ribs of two sizes. *N. lorioli* Pictet and Campiche (1862, p. 406, pl. 76, figs. 5a, b) has similar ornamentation but is much larger and its body whorl is not flattened posteriorly.

Specimen.—No. 21356, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Atlantic Refining Company's Spain No. 1 well at depth of 7565–66 feet, sec. 18, T. 17 S., R. 19 W., Columbia Co., Arkansas.

Genus XYSTRELLA Cossmann, 1906
XYSTRELLA? aff. X. PAPILLOSA
(Deslongchamps)
Plate 39, figures 3–5

This species is represented by two external molds, which do not show the extremities of the shell. Shell small, turreted, not very long. Sutures deep. Whorls eight or more, increasing regularly in size, flattened, nearly twice as wide as high. Whorls ornamented with two very strong spiral ribs and by eight strong axial ribs. In addition, one weak spiral rib occurs on the medial part of the larger whorls. The axial ribs succeed each other from whorl to whorl in a tortuous manner from left to right. The intersection points of the two sets of ribs are produced as prominent blunt tubercles.

Remarks.—This species is remarkably similar to *X. papillosa* (Deslongchamps) (Hudleston, 1889, p. 183, pl. 11, fig. 13; Cossmann, 1913, p. 86, fig. 22) from the Middle Jurassic of Europe but appears to have more prominent tubercles.

Specimens.—Nos. 21366, 21372, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, (1) Atlantic Refining Company's Levi Garrett No. C-1 well at depth of 7476 feet, sec. 13, T. 17 S., R. 20 W., Columbia County, Arkansas; (2) Atlantic Refining Company's Spain No. 1 well at depth 7566–67 feet, sec. 18, T. 17 S., R. 19 W., Columbia County, Arkansas.

Genus CRYPTOPTYXIS Cossmann, 1906
CRYPTOPTYXIS? DIVERSICOSTATA
Imlay, n. sp.
Plate 39, figures 6, 7

The species is represented by one external mold, which does not show the extremities of the shell. Shell small, turreted, spire fairly long and regular. Suture fairly shallow. Whorls eight or more, hexagonal or pentagonal, increasing regularly in size, flattened, more than half as high as wide. Whorls ornamented with four or five spiral ribs and probably six axial ribs. Two of the spiral ribs are much stronger than the others. One or two of the weaker spiral ribs occupies the middle of the whorl, and another lies immediately posterior to the suture. The axial ribs are very strong, succeed each other with a twist from left to right, and rise into tubercles at their intersections with the spiral ribs.

Remarks.—This species bears ornamentation similar to *Exelissa normaniana* (d'Orbigny) (Cossmann, 1913, p. 115, pl. 5, figs. 12–14) but cannot be placed in that genus because of its turreted, pyramidal form and small number of axial ribs. The latter feature suggests a position in *Cryptoptyxis* Cossmann (1906, p. 39) rather than *Xystrella* Cossmann (1906, p. 26).

Specimen.—No. 21368, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Atlantic Refining Company's Levi Garrett No. C-1 well at depth of 7476 feet, sec. 13, T. 17 S., R. 20 W., Columbia County, Arkansas.

CRYPTOPTYXIS? FORMOSA Imlay, n. sp.
Plate 39, figures 8, 9

The species is represented by one external mold, which shows the body whorl. Shell small, turreted, spire fairly long, suture distinct. Whorls seven or more, heptagonal, increasing regularly in size, half as high as wide. Whorls of spire ornamented with seven axial and six to eight spiral ribs. Each whorl bears two strong spiral ribs, which divide the surface of the whorl into three nearly equal parts. In addition, the penultimate whorl bears six weak spiral ribs, which alternate in pairs with the strong ribs. The earlier-formed whorls of the spire bear fewer weak spiral ribs but not less than four on any of the preserved whorls. The body whorl is ornamented like the penultimate whorl but bears about six additional weak spiral ribs on its anterior part. The seven axial ribs are very strong, succeed each other

with a slight twist from right to left, rise into prominent tubercles at their intersections with the spiral ribs, and disappear abruptly on the anterior part of the body whorl. The size and prominence of the intersection tubercles varies directly as the strength of the spiral ribs. The body whorl is more than twice as high as the penultimate whorl.

Remarks.—This species may be distinguished easily from *Cryptoptyxis? diversicostata* Imlay by its larger number of axial and spiral ribs and by its more vigorous ornamentation. *Exelissa normaniana* (d'Orbigny) as figured by Cossmann (1913, p. 115, pl. 5, figs. 12–14) has somewhat similar ornamentation but has a pupoidal instead of a conical form. The large number of axial ribs in the Arkansas species suggests that it belongs in *Exelissa* rather than *Cryptoptyxis*, but its conical shape and the coarseness of its axial ribs are more like *Cryptoptyxis*. Its ornamentation resembles considerably "*Pseudocerithium*" *contortum* Brösamlen (1909, p. 290, pl. 21, fig. 25) but not *Cryptaulax contortum* (Eudés-Deslongchamps) as figured by Cossmann (1913, p. 102, pl. 4, figs. 83–84, pl. 5, fig. 113, pl. 10, figs. 31–33). The species figured by Brösamlen comes from the Middle Jurassic of Schwabia and is distinguished from the Arkansas species by its fewer axial ribs.

Specimen.—No. 21377, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Atlantic Refining Company's Spain No. 1 well at depth of 7566–67 feet, sec. 18, T. 17 S., R. 19 W., Columbia County, Arkansas.

CRYPTOPTYXIS? aff. C. GRIMALDII
(Guirand and Ogerien)
Plate 39, figures 1, 2

This species is represented by one external mold, which shows most of the shell. Shell small, turreted, pyramidal, spire moderately long. Sutures fairly deep. Whorls eight or more, probably hexagonal, increasing regularly in size, flattened, a little more than half as high as wide. Whorls of spire ornamented with three strong spiral ribs and probably six axial ribs. The lowest spiral rib is the strongest. In addition a faint spiral rib occurs immediately anterior to the suture. The axial ribs are very strong, succeed each other in a tortuous manner, and rise into tubercles at their intersections with the spiral ribs. The last whorl is about twice as high as the preceding whorl.

Remarks.—This species greatly resembles *C. grimaldii* (Guirand and Ogerien) (P. de Loriol, 1887, p. 124, pl. 12, figs. 11–13; Cossmann, 1913, p. 111, pl. 5, figs. 26–29, pl. 7, fig. 18, pl. 11, figs. 7–8) but probably has six instead of five axial ribs, is much smaller, and differs in details of ornamentation.

Specimens.—Nos. 21365, 21378, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Atlantic Refining Company's Levi Garrett No. C-1 well at depth of 7475½ feet, sec. 13, T. 17 S., R. 20 W., Columbia County, Arkansas.

Genus GYMNOCERITHIUM Cossmann, 1906
GYMNOCERITHIUM? aff. G. JOSEPHENSE
(P. de Loriol)
Plate 39, figure 13

The species is represented by one incomplete external mold. Shell elongate, turreted. Apical angle about 17°. Sutures well marked. Whorls numerous (only eight preserved), increasing gradually in size, slightly convex, about two-fifths as high as wide. Whorls ornamented by numerous fine, threadlike, spiral ribs and by faint flexuous growth lines. The spiral ribs vary somewhat in size and are separated by narrower interspaces. Posterior margin of each whorl adjacent to suture is slightly elevated but is not granulated or tuberculated. Body whorl not preserved.

Remarks.—This species greatly resembles *G josephense* (P. de Loriol) (1887, p. 132, pl. 13, figs. 6a, b; Cossmann, 1913, p. 252, pl. 11, fig. 24), from the Kimmeridgian of Switzerland, in shape and ornamentation but may be distinguished by less marked sutures and by a slight swelling on the anterior side of each suture.

Specimen.—No. 21379, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Atlantic Refining Company's Spain No. 1 well at depth of 7566–67 feet, sec. 18, T. 17 S., R. 19 W., Columbia County, Arkansas.

Genus PHANEROPTYXIS Cossmann, 1896
PHANEROPTYXIS? ANGULATA Imlay, n. sp.
Plate 39, figures 14–16

The species is represented by two external molds. Shell small, conical, moderately tur-

reted. Apical angle about 25°. Sutures distinct. Spire pointed, steplike, whorls numerous, embracing, slightly convex, about three-fifths as high as wide. Last whorl subcylindrical, apparently a little less than half the height of the entire shell. Aperture apparently long and narrow, canaliculate posteriorly. Suture bordered by a narrow shelf, which terminates in a weak carina. Surface below shelf ornamented with about 10 axial ribs, which are strong and nodular near the shelf but become indistinct on lower part of whorls. Surface faintly marked by sinuous growth striae, which are retrocurrent to the suture. Dimensions of specimen figured on pl. 39, figs. 15, 16: altitude (incomplete), 13 mm.; maximum diameter, 5.7 mm.

Remarks.—The generic determination of this species must remain uncertain pending knowledge of the characters of its inner lip. However all known characters are like those of *Phaneroptyxis* and particularly the type species, *P. moreana* (d'Orbigny) (1851, p. 100, pl. 257, figs. 1, 2; also Cossmann, 1898, p. 14, pl. 2, figs. 1, 2), from the upper Oxfordian and lower Kimmeridgian of Europe. From *P. moreana* the Arkansas species may be distinguished by its smaller size, more steplike spire, and relatively more prominent axial ribs. As *P. moreana* is highly variable (Cossmann, 1898, p. 17), some of its immature forms are possibly more like the Arkansas species than published illustrations would indicate.

Type.—Holotype 21352, paratype 21347, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Phillips Petroleum Company's Arnold No. 1 well at depth of 4946–56 feet, sec. 27, T. 15 S., R. 15 W., Ouachita County, Arkansas.

Genus NERINEA Defrance, 1825

NERINEA aff. N. EUDESII Morris and Lycett

Plate 39, figures 11, 12

Shell turreted, not very attenuated, apical angle about 20°. Whorls seven or more, slightly more than twice as wide as high, concave. Suture closely appressed, marked by a low ridge. Surface of each whorl ornamented with five or six spiral ribs, which alternate in strength and are fairly regularly spaced. Two of the stronger ribs are on the anterior half of the whorl. One of the weaker ribs occupies the bottom of the concavity of each whorl. Growth lines faint. Height (incomplete), 15 mm.; diameter, 7 mm.

Remarks.—This form differs from *Nerinea goodelli* Cragin (1905, p. 96, pl. 21, figs. 1–3) by having a much greater apical angle and more spiral ribs per whorl. It bears considerable resemblance to *N. eudesii* Morris and Lycett (1851, p. 33, pl. 7, figs. 6, 6a) from the Middle Jurassic of England, but its sutural ridges are less prominent.

Specimen.—No. 21371, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Atlantic Refining Co., Levi Garrett No. C-1 well at depth of 7476½ feet, sec. 13, T. 17 S., R. 20 W., Columbia County, Arkansas.

NERINEA cf. N. TURBATRIX P. de Loriol

Plate 39, figures 17–20

Four external molds belong to a large elongate species with an apical angle of about 15°. Whorls 15 or more, slightly more than half as high as wide, very concave in middle but becoming less concave anteriorly, much swollen at anterior margin above suture. Suture closely appressed, inclined slightly oblique to axis of spire. Surface nearly smooth, marked by exceedingly faint sinuous growth lines. Aperture unknown.

Remarks.—This species greatly resembles *Nerinea turbatrix* P. de Loriol (1886, p. 90, pl. 8, figs. 1, 2; Cossmann, 1898, p. 60, p. 5, fig. 19) from the Upper Jurassic of Europe but appears to have relatively higher whorls and a smaller apical angle. Somewhat less similar forms are known from the Lower Cretaceous. *Nerinea gigantea* d'Hombres-Firmas (d'Orbigny, 1842, p. 77, pl. 158, figs. 1, 2) has wider, less concave whorls, which are swollen at both their anterior and posterior margins.

Specimens.—Nos. 21349, 21350, 20441, 17691, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Phillips Petroleum Company, J. T. Arnold No. 1 well at depth of 4946–56 and 5067–77, sec. 27, T. 15 S., R. 15 W., Ouachita County, Arkansas.

NERINEA aff. N. GOODELLII Cragin

Plate 39, figure 10

The species is represented by one external

mold. Shell turreted, attenuated, apical angle about 10°. Whorls 14 or more, about twice as wide as high, concave. Suture closely appressed, marked by a low, sharp ridge. Whorls on upper part of spire ornamented with four weak spiral ribs. Whorls on lower part of spire ornamented with five weak spiral ribs and two or three faint spiral lines. Growth lines very faint, slightly oblique. Height (incomplete), 25 mm., diameter, 6 mm.

Remarks.—This species greatly resembles *Nerinea goodellii* Cragin (1905, p. 96, pl. 21, figs. 1–3) and apparently differs only by the presence of one additional main spiral rib per whorl, by faint spiral lines on the lower part of the spire, and by a slightly larger apical angle.

Specimen.—No. 21357, Museum of Paleontology, University of Michigan.

Occurrence.—Smackover limestone, Atlantic Refining Co., Spain No. 1 well at depth of 7566–67 feet, sec. 18, T. 17 S., R. 19 W., Columbia County, Arkansas.

Ammonite fragments
Plate 38, figures 35, 36

A few small ammonite fragments were obtained from sandy shales of the Smackover formation at depths of 10,545–50 and 10,640–45 feet in the Texas Company's T. C. Adams estate No. C-1 well, located in the Bethany gas field of Panola County, Texas. The highest ammonite bed lies about 515 feet above the bedded salt of the Eagle Mills formation and 8273 feet below the top of the Lower Cretaceous. The character of the ribbing of several specimens and the presence of a ventral groove on one specimen were suggestive to the writer of perisphinctoids of the Upper Jurassic. Photographs of the ammonites were sent to Dr. L. F. Spath of the British Museum of Natural History, who reported concerning the largest specimen (pl. 38, fig. 36) that it

> may indeed be a perisphinctoid (or berriasellid) of Upper Jurassic or Lower Cretaceous age, or it may not, for there are earlier Jurassic and even Liassic genera (e.g., *Dactylioceras*) that could look like your crushed specimen. I do not say that such an earlier genus is more probable than a perisphinctoid or some Lower Cretaceous berriasellid, and it may even be ruled out (apparently) by other considerations or geological inferences . . .

Specimens.—Nos. 21530, 21531, Museum of Paleontology, University of Michigan.

Genus Estheria Ruppell and Straus-Dürkheim, 1837
Estheria spp.
Plate 39, figures 22–29

The Buckner formation and the lower part of the Cotton Valley formation have yielded several species of *Estheria*, with which are associated other brackish or fresh water organisms including *Cyrena?*, *Planorbis*, *Volsella?*, and cyprid ostracods.

The most abundant species of *Estheria*, shown on pl. 39, figs. 22–24, may be compared with *E. murchisoniae* Jones (1863, p. 100, pl. 3, figs. 1–12) from the Jurassic oolites of Scotland. Likewise *E. subquadrata* (Sowerby) (Jones, 1863, pp. 103–109, pl. 3, figs. 18–29; 1890, p. 389, pl. 12, figs. 1, 2a, 2b), from the Purbeck (Upper Jurassic) and Wealden (Neocomian) of England, is somewhat similar but appears to have more prominent umbones.

Another species, shown on pl. 39, figs. 25–29, bears much wider spaced concentric ridges and is comparable with the South American *E. forbesii* Jones (1863, p. 109, pl. 4, figs. 8–11) in ornamentation and shape. Two specimens show crowding of the ridges near their ventral margins and might be regarded as transitional to the first-mentioned Louisiana species.

Slabs.—Nos. 21528, 21529, Museum of Paleontology, University of Michigan.

Occurrence.—Cotton Valley and Buckner formations in the Furlong-Clark No. 1 well, Morehouse Parish, Louisiana. *Estheria* cf. *E. murchisoniae* Jones was obtained from cores at depths of 5240–42, 5255–56 feet in the Cotton Valley formation and at 5903–04 feet in the Buckner formation. *E.* cf. *E. forbesii* Jones was obtained at the depth of 5903–04 feet.

References

Arkell, W. J., *1929–1937*, A monograph of British Corallian Lamellibranchia: *Palaeontographical Soc.*, vols. 81–90, illust.

——, *1930*, The generic position and phylogeny of some Jurassic Arcidae: *Geol. Mag.*, vol. 67, pp. 297–310, 337–352, pls. 14–16.

——, *1933*, *The Jurassic system in Great Britain*. Clarendon Press, Oxford.

Boehm, G., *1883*, Die Bivalven der Stramberger Schichten: *Palaeontographica, Sup.* 2. Cassel.

——, *1893*, *Coelastarte* und *Heteropis: Naturf. Gesell. Freiburg, Ber.*, Band 7, Heft 2, pp. 169–178, pl. 8.

BRÖSAMLEN, RICHARD, *1909*, Beitrag zur Kenntnis der Gastropoden des schwäbischen Jura: *Palaeontographica*, Band 56, pp. 177–322, pls. 17–22.

BURCKHARDT, CARLOS, *1930*, Étude synthétique sur le mesozoïque mexicain: *Schweizer. palaeont Gesell., Abh.*, Band 49–50, 280 pp., 11 tables, 32 figs.

COSSMANN, M., *1895–1925*, *Essais de paléoconchologie comparée*, t. 1–13. Paris.

——, *1898*, Contribution à la paléontologie française des terrains jurassiques; Gastropodes; Nérinées; *Soc. geol. France, Mém.* 19, t. 8, 180 pp., 13 pls.

——, *1906–1922*, Description de quelques pelecypodes jurassiques de France: *Assoc. franç. av. sci., Comptes rendus.*

——, *1913*, Contributions à la paléontologie française des terrains jurassiques; Gastropodes; Cerithiacea et Loxonematacea: *Soc. geol. France, Mém.* 46, t. 19, 20, 264 pp., 11 pls.

COX, L. R., *1929*, Notes on the Mesozoic family Tancrediidae, with descriptions of several British Upper Jurassic species, and of a new genus, *Eodonax: Annals and Mag. Nat. History*, ser. 10, vol. 3, pp. 569–94, pls. 13, 14.

CRAGIN, F. W., *1905*, Paleontology of the Malone Jurassic formation of Texas: *U. S. Geol. Survey, Bull.* 266, 172 pp., 29 pls.

DACQUÉ, E., *1934*, *Wirbellose des Jura, Leitfossilien* (*Georg Gürich*), Lief. 7, 582 pp., 48 pls., 3 text figs. Gebrüder Borntraeger, Berlin.

DIETRICH, W. O., *1933*, Zur Stratigraphie und Palaeontologie der Tendaguru-schichten: *Palaeontographica, Sup.* 7, ser. 2, pt. 2.

GOLDFUSS, A., and MÜNSTER, G., *1826–44*, *Petrefacta Germaniae*, vol. 2.

GREPPIN, E., *1888*, Description des fossiles de la Grande Oolithe des environs de Bâle: *Schweizer. palaeont. Gesell., Abh.*, Band 15, 137 pp., 10 pls.

——, *1898–1899*, Description des fossiles du Bajocien supérieur des environs de Bâle: *idem.*, Band 25–26, 126 pp., 12 pls.

HUDLESTON, W. H., *1887–1895*, A monograph of the British Jurassic Gasteropoda: *Palaeontographical Soc.*, vols. 40–43, 45, 46, 48, 49; 444 pp., 40 pls.

IMLAY, R. W., *1937*, Geology of the middle part of the Sierra de Parras, Coahuila, Mexico: *Geol. Soc. America, Bull.*, vol. 48, pp. 587–630, 14 pls., 4 figs.

——, *1938*, Studies of the Mexican geosyncline: *Geol. Soc. America, Bull.*, vol. 49, pp. 1651–1694, 7 pls., 6 figs.

——, *1940a*, Lower Cretaceous and Jurassic rocks of southern Arkansas and their oil and gas possibilities: *Arkansas Geol. Survey, Information Circular* 12, 64 pp., 26 pls., 17 tables.

——, *1940b*, Upper Jurassic pelecypods from Mexico: *Jour. Paleontology*, vol. 14, no. 5, pp. 393–411, pls. 50–56, 1 fig., 3 tables.

JONES, T. R., *1863*, A monograph of the fossil Estheriae: *Palaeontographical Soc.*, vol. 14, pp. X, 1–134, pls. 1–5.

——, *1890*, On some fossil Estheriae: *Geol. Mag.* ser. 3, vol. 7, pp. 385–390, pl. 12.

LORIOL, P. DE, *1868*, Monographie paléontologique et géologique de l'étage Portlandien du département de l'Yonne: *Soc. sci. de l'Yonne, Bull.*, vol. 21 (1867), pp. 437–696, pls. 1–15.

——, *1886–88*, Études sur les mollusques des couches coralligènes de Valfin (Jura): *Schweizer. palaeont. Gesell., Abh.*, Band 13–15, illust.

——, *1889–93*, Études sur les mollusques des couches coralligènes du Jura bernois; *idem*, Band 16–19, illust.

LYCETT, J., *1863*, A supplementary monograph on the Mollusca from the Stonesfield Slate, Great Oolite, Forest Marble, and Cornbrash: *Palaeontographical Soc.*, vol. 15, 129 pp., pls. 31–45.

——, *1872–83*, A monograph of the British fossil Trigoniae: *idem*, vols. 26, 28, 29, 31, 33, 35, 37, illust.

MORRIS, J., and LYCETT, J., *1851–1855*, A monograph of the Mollusca from the Great Oolite, chiefly from Minchinhampton and the coast of Yorkshire: *idem*, vols. 4, 7, 8.

ORBIGNY, A. D', *1840–1847*, *Paléontologie française, Terrains Crétacés; 1840–1842*, t. 1; *1842–1843*, t. 2; *1844–1847*, t. 3; illust. (For exact dates of publication see SHERBORN, D., *1899*, *Geol. Mag.*, ser. 4, vol. 6, pp. 223–225.)

——, *1842–1891*, *Paléontologie française, Terrains Jurassiques, 1842–1851*, t. 1; *1851–1860*, t. 2; *1891*, t. 3; illust.

PICTET, F. J., and CAMPICHE, G., *1858–1872*, Description des fossiles du terrain crétacé des environs de Sainte Croix: *Materiaux pour la paléontologie suisse*, illust.

ROLLIER, L., *1912–1917*, Fossiles nouveaux ou peu connus des terrains secondaires du Jura et des contrées environnantes: *Schweizer. palaeont. Gesell., Abh.*, Band 37–42, illust.

SOWERBY, J. DE C., *1823–1829*, *The mineral conchology of Great Britain*, vols. 5, 6, illust.

WEEKS, W. B., *1938*, South Arkansas stratigraphy with emphasis on the older Coastal Plain beds: *Am. Assoc. Petroleum Geologists, Bull.* vol. 22, no. 8, pp. 953–983, 5 figures.

MANUSCRIPT RECEIVED BY THE EDITOR JUNE 22, 1940

JOURNAL OF PALEONTOLOGY, VOL. 15, NO. 3, PP. 278–279, 2 TEXT FIGS., MAY, 1941

A NEW CORAL FROM THE PLIOCENE OF CALIFORNIA

J. WYATT DURHAM
University of California, Berkeley, Calif.

ABSTRACT—Two corals are commonly present in material from the San Joaquin clay, upper Pliocene of California. One is *Astrangia coalingensis* Vaughan, of which a description is given; the new species is described as *Rhizopsammia arnoldi* Durham, n. sp.

EXAMINATION of corals in collections from the San Joaquin clay near Coalinga, Calif., revealed the presence of two genera in material commonly referred to *Astrangia coalingensis* Vaughan (1910). Sixty out of eighty specimens in the University of California collections were found to represent a new species which is here described.[1]

Genus RHIZOPSAMMIA Verrill, 1871

Rhizopsammia VERRILL, *1871*, Connecticut Acad. Arts and Sci., Trans., vol. 1, p. 510.

Genotype (monotypic), *Rhizopsammia pulchra* Verrill (1871).

RHIZOPSAMMIA ARNOLDI Durham, n. sp.
Figures 1, 2

Corallum low, encrusting, corallites turbinate, connected by base, occasionally interlocking. Corallum superficially very similar to *Astrangia coalingensis* Vaughan, with which it has been confused. Individual corallites as large as 8 mm. high and 7 mm. in diameter, usually about 4 mm. in diameter and 6 mm. tall. Wall costate, perforations in intercostal grooves. A thin coating of epitheca on older and larger specimens, not found on smaller specimens. Calice as much as 2.5 mm. deep, columella inconspicuous. Septa in four cycles in a typical eupsammid pattern, first and second cycles slightly exsert, second cycle about half the size of first cycle. Septa thin, one-third to one-half the width of interspaces. Septal granules abundant. Upper edge of septa finely dentate, no paliform lobes apparent. Columella formed by fusion of inner ends of septa, slightly elongate.

Holotype no. 12227, paratypes nos. 12229, 12236, 12237 (Univ. California Mus. Paleontology), no. 2289 (California Acad. Sci. Paleo Type Coll.).

[1] Assistance in the preparation of this manuscript was furnished by the personnel of the Works Progress Administration, Official Project no. 65-1-08-62, Unit A-1.

Occurrence.—Kings County, California: U. C. Mus. Pal. locality 2991, near center of SE ¼, sec. 17, T. 22 S., R. 16 E., on top of ridge south of road; locality 2996, near NE cor. sec. 34, T. 21 S., R. 17 E.; locality A-3448, sec. 12, T. 23 S., R. 18 E. Upper Pliocene, *Pecten coalingensis* zone, San Joaquin clay.

Comparisons.—This species may be distinguished from *Rhizopsammia pulchra* Verrill by the second cycle of septa being only about half the size of the first cycle, and by the absence of paliform lobes. It may easily be separated from *Astrangia coalingensis* Vaughan by the perforate wall and septa and the eupsammid septal pattern. Both species may be found growing on the same boulder. As no description of *Astrangia coalingensis* Vaughan has ever been published, the following description is presented.

ASTRANGIA COALINGENSIS Vaughan
Figure 1a

Astrangia coalingensis VAUGHAN, in ARNOLD (*nomen nudem*), *1909*, U. S. Geol. Surv., Bull. 396, p. 34 (check list).

Astrangia coalingensis VAUGHAN, in ARNOLD, *1910*, U. S. Geol. Surv., Bull. 398, p. 128, pl. 45, fig. 3.

Holotype: U. S. Nat. Mus. no. 15566.

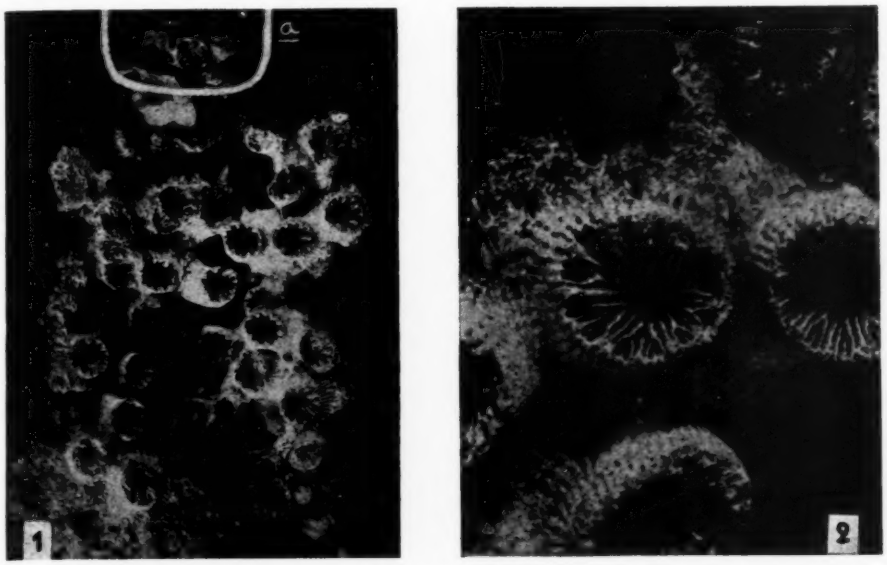
Hypotypes: Univ. California Mus. Paleontology nos. 12238, 12243, and 12249.

Corallum encrusting or glomerate. The corallites are usually free except near base, though hypotype no. 12249 is composed of a mass of corallites so closely crowded that their walls have locally fused, the corallites are also exceptionally tall in this specimen, some reaching a height of 30 mm., with a diameter of 5 mm. In normal specimens, the average height above the base is about 9 or 10 mm., with a diameter of 5 to 6 mm. The calice is ordinarily 3 to 4 mm. deep. Costae corresponding to septa, finely granulate, disappearing toward the base. Septa in four

cycles, apparently not exsert in adult, all except fourth cycle reaching columella, which is formed by fusion of paliform lobes from inner edges of septa. First three cycles of equal size. Upper edge of septa dentate, lower edge towards columella with three to four paliform teeth. Septal granules abundant.

This species closely resembles the description of *A. haimei* Verrill (1871) from Panama and the Pearl Islands but may possibly be distinguished from it by the usually lesser number of septa and sharper septal denticles of that species.

Occurrence.—Same as *Rhizopsammia arnoldi* Durham, n. sp.



FIGS. *1, 2—Rhizopsammia arnoldi* Durham, n. sp. Holotype. *1*, ×1.37; *2*, detail of calices, ×6.
1a—Astrangia coalingensis Vaughan, ×1.37, growing on the same block of sandstone as *Rhizopsammia arnoldi*.

A CONTRIBUTION FROM THE MUSEUM OF PALEONTOLOGY, UNIVERSITY OF CALIFORNIA, BERKELEY, CALIF. MANUSCRIPT RECEIVED BY THE EDITOR OCTOBER 21, 1940.

JOURNAL OF PALEONTOLOGY, VOL. 15, NO. 3, PP. 280–284, PLS. 40, 41, MAY, 1941

NEW CORALS: ONE RECENT, ALASKA; THREE EOCENE, ALABAMA AND LOUISIANA

THOMAS WAYLAND VAUGHAN
U. S. National Museum, Washington, D. C.

THE FOUR NEW species of corals described in this paper are *Carophyllia alaskensis*, Recent, from southeast Alaska, depths 150 to 399 m., temperature 6.1°C.; *Archohelia gardnerae*, from the Eocene Lisbon formation of Alabama; *Archohelia vernonensis*, from Vernon Parish, La., associated with a fauna of Eocene lower Claiborne St. Maurice age, but the associated fauna may not be in place; *Goniopora aldrichi*, from the Eocene Wilcox Bashi marl, 6 miles east of Thomasville, Ala.

DESCRIPTIONS OF SPECIES

Genus CARYOPHYLLIA Lamarck, 1801

CARYOPHYLLIA ALASKENSIS Vaughan, n. sp.

Plate 40, figures 1–4

Corallum inversely subconical, attached at its truncate apex by a thin spreading basal expansion. Transverse outline subcircular.

The corallum gradually enlarges upward from the base.

The wall is thin on its upper edge but evidently thickened below. Outer surface smooth, shiny or with faint granulations; costae obsolete, although indicated they are not distinct, even at the calicular edge.

Septa normally in four complete cycles; rudimentary quinaries may be present, margins very slightly exsert; primaries and secondaries about 1 mm.; tertiaries and quaternaries slightly more than 0.5 mm.; quinaries, when present, are not indicated on the upper edge of the wall. The septa are comparatively thin in the upper part of the corallum, and the interseptal loculi appear correspondingly open and deep. The septa are nearly equal in thickness, the primaries and secondaries being slightly thicker. Primaries and secondaries equal in length, extending inward to near the columella, and appearing to fuse to it deep down in the calice. Tertiaries shorter, with a wide, undulate palus before each one; quaternaries slightly shorter than the tertiaries. Inner septal margins perpendicular. Septal faces with numerous small granulations.

Pali undulate, wide, in a single crown before the tertiary septa, which they equal in length; granulations on their faces similar to those on the septa.

Columella rather large, composed of curled ribbons; its upper surface only slightly or very considerably depressed below the upper mural edge.

Measurements

Specimen	Station	Base above expansion		Calice[1]		Height
		Greater diameter	Lesser diameter	Greater diameter	Lesser diameter	
No. 1	4231	4 mm.	3.5 mm.	10.25 mm.	9.5 mm.	13 mm.
No. 2	4231	4	3.5	10	10	17.3
No. 3	4300	5	4.5	10.25	9.5	13

[1] Measurements between thecal summits.

Localities.—*Albatross* station 4231, vicinity of Naha Bay, Behm Canal, southeast Alaska; depth, 82 to 113 fm. (150 to 208 m.); temperature of bottom, 43°F. (6.1°C.), a subpolar temperature.

Albatross station 4300, off Shakan, Summer Strait, southeast Alaska; depth, 185 to 218 fm. (338 to 399 m.).

Syntypes.—U. S. Nat. Mus. 547317 (figured), 547318.

Remarks.—The principal variations shown are in the number of the septa and the depth of the calice. Very small quinary septa are present in specimen no. 1 of the

table; they seem to be indicated in specimen no. 2; and are altogether absent in no. 3, in which there are only 11 pali instead of the usual 12. The calice in specimen no. 1 is shallow; that of no. 2 is moderately deep, 5 or 6 mm.; that of no. 3 is of intermediate depth.

Specimens somewhat smaller than the syntypes of *C. alaskensis* but which represent the same or a closely related species were collected by Rev. Geo. W. Taylor at several places in the coastal waters of British Columbia. *Balanophyllia elegans* Verrill is an associated species.

The species of *Caryophyllia* known from the Pacific side of America from Panama north are as follows: *C. arnoldi* Vaughan, *C. pedroensis* Vaughan, and *C. californica* Vaughan (1903, pp. 86–87), Pleistocene and Pliocene fossils from California, and *C. diomedeae* v. Marenzeller (1904, p. 79, pl. 1, fig. 2), off Panama, lat. 6°30′ N., long. 81°44′ W.; depth, 1,043 m. As *C. alaskensis* is not very close to any one of these, critical remarks are unnecessary.

Genus ARCHOHELIA Vaughan, 1919

ARCHOHELIA GARDNERAE Vaughan, n. sp.

Plate 41, figures 1–7

The following is a description of syntypes from U. S. Geological Survey locality 14837, 1 mile southeast of True Light Church, Washington County, Ala., collected by Julia A. Gardner, for whom the species is named:

Corallum ramous, terminal branchlets rather slender. The dimensions of five pieces are as follows:

Dimensions of branches (mm.)

No.	Length	Diameter of upper end	Diameter of lower end	Illustration
1	32	6	6.5	Pl. 41, fig. 1
2	28	5.5	8×7	Pl. 41, fig. 2
3	38	9.5	11	
4	51	7.5	10.5	Pl. 41, figs. 3–5
5	22	12	14	

The actual diameter of the tip of a branch end is not shown, as all branches are broken, but as the diameter of the axial corallite-cavities ranges between 3 and 5 mm., the diameter of the terminal corallite would be slightly greater, probably between 4 and 6 mm.

A more basal piece (pl. 41, fig. 6) is 52 mm. long; 13 mm. in diameter at the lower end; 18 by 14 mm. in diameter about midway between the ends; at upper end, trifurcating; basal diameter of the lower branch, about 16 mm.

The axial corallite cavities range in diameter from 3 to 5 mm., as stated above. The number of septa is about 24, of which 10 to 12 reach the columellar region. The lateral corallites are in more or less distinct spirals. The diameter of normal calices, measured across the walls, ranges from 1.75 to 3.72 mm. The diameter of some large calices is 5 mm., the same as that of the axial corallites. The distance apart in general exceeds the calicular diameter (for details see the illustrations). The calicular margins are slightly or moderately elevated, usual range between 0.65 and 1.85 mm. A few calices are more prominent, as large as 2.8 mm. or even somewhat more. The calicular depth ranges from about 0.65 to about 1.0 mm.

In the smaller calices, such as those of specimen no. 1 of the foregoing table, there are six larger septa, between each pair of which there are three smaller septa, the last cycle being very small or rudimentary. There is some lax fusion between the inner ends of the large septa. The septal margins are damaged, but apparently above the bottom of the calice the septa are narrow. In the larger calices, such as those of specimen no. 4 of the table, the septal scheme is three cycles with a rudimentary fourth cycle represented by costae on the upper edge and on the outer surface of the wall. Both the primary and secondary septa and about half the tertiaries reach the columella tangle. There is indistinct septal grouping between the primaries. On a few septa dentations similar to those of other species of the genus seem to be preserved.

In the larger lateral corallites the columella is well developed and is composed of the curled and interfused inner ends of the longer septa, with a papillate or curly upper surface.

Dissepiments are present.

The costae round the calicular edge are low, flattish, and equal; they extend out on the coenenchymal surface, especially on the proximal sides of the corallites. Outside the costal prolongations the coenenchymal sur-

faces may be minutely striate, granulate, or apparently smooth. The texture of the coenenchyma is dense.

Paratypes.—At another place on the same exposure, U. S. Geological Survey locality 14839, some of the specimens show branch terminals better than the syntypes. One of these specimens is illustrated (pl. 41, fig. 7). The diameter of the axial corallite measured between the outer surfaces of the walls is 4.65 mm. Some corallites on this specimen are decidedly prominent, one projects 4.2 mm. Some septal margins are well preserved and show the dentations usual in the genus. The axial corallite of another tip is 4.2 mm. in diameter.

Types.—Syntypes, U. S. Nat. Mus. 547325 (figured), 547326. Paratypes, 547327 (figured), 547328.

Comparisons.—The differences between *Archohelia gardnerae* and *A. vernonensis* are obvious. In the former more than twelve septa in the lateral corallites reach the columella, whereas in the latter species only six do so. *A. singleyi* (Vaughan) (=*Oculina singleyi* Vaughan) (1900, p. 120, pl. 12, figs. 1–3a) from Smithville, Tex., is closer. The higher cycles of septa in that species are more developed than in *A. gardnerae*, and the septal margins and faces are rougher.

Occurrence.—In addition to the locality above mentioned, the species was also collected in Alabama as follows: U. S. Geol. Survey locality 14785 N, Little Stave Creek, Clarke County, Ala., first *Ostrea sellaeformis* bed, Julia A. Gardner, collector. Locality 14786, Sowilpa Creek, Choctaw County, Julia A. Gardner, collector. Locality 14788, 1.7 miles north of Cullomberg, Choctaw County, C. W. Cooke, collector.

Geological horizon.—Middle Eocene, Lisbon formation.

Associated corals.—The following table shows the species of corals associated with *Archohelia gardnerae.*

Species of corals associated with Archohelia gardnerae

Names	Locality numbers				
	14785 N	14786	14788	14837	14839
Flabellum cuneiforme var. *pachyphyllum* Gabb and Horn				×	×
Turbinolia pharetra Lea					×
Archohelia gardnerae Vaughan, n. sp.	×	×	×	×	×
Discotrochus orbignianus Milne Edwards and Haime				×	×
Endopachys maclurii (Lea)					×
Balanophyllia desmophyllum Milne Edwards and Haime					
Balanophyllia irrorata (Conrad) var.					×
Dendrophyllia lisbonensis Vaughan	×				

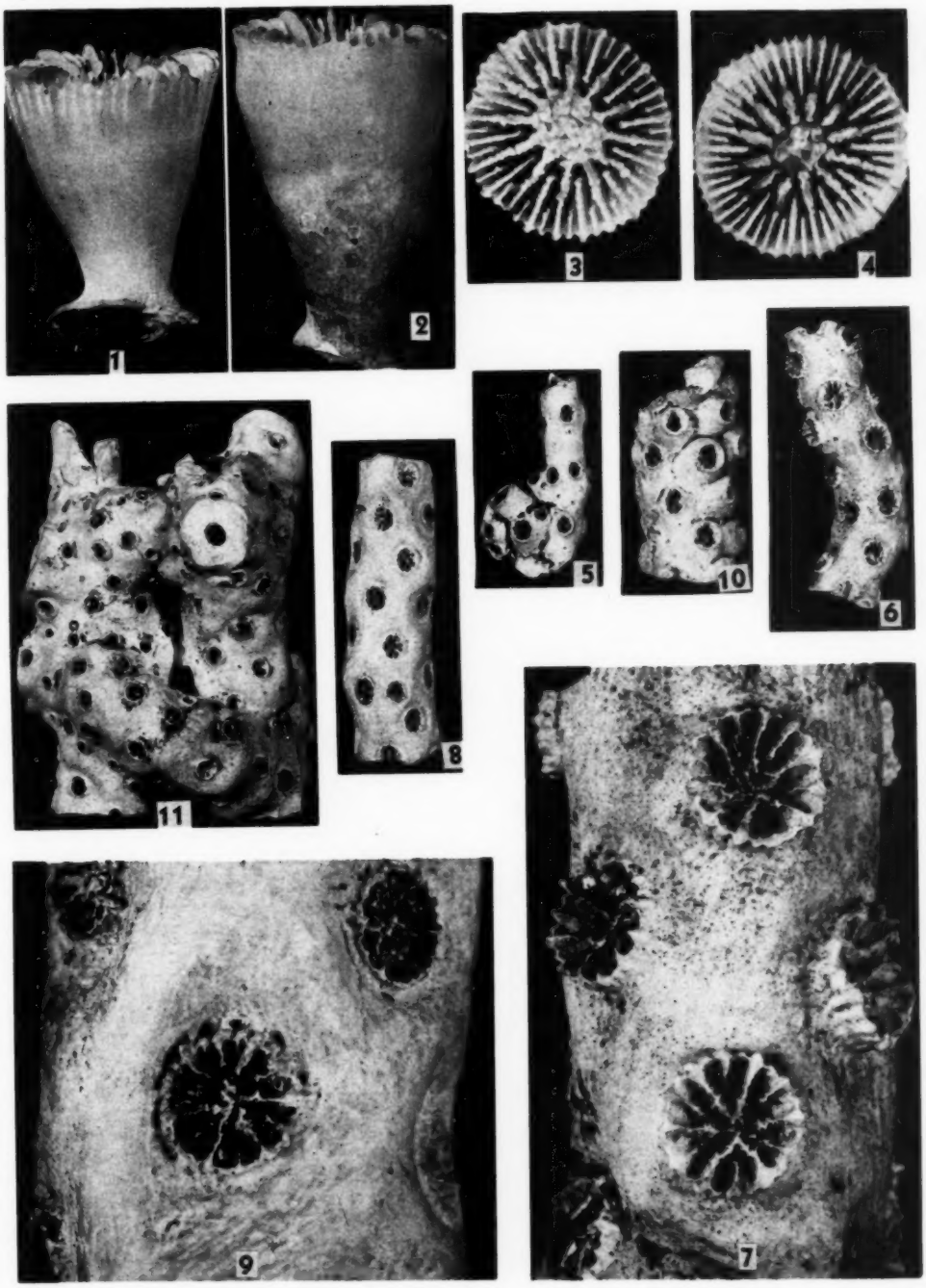
ARCHOHELIA VERNONENSIS
Vaughan, n. sp.
Plate 40, figures 5–11

Corallum ramous, with considerable coalescence of branches in the lower part of the colonies. Since only broken branches are available the dimensions of an intact colony are not determinable, but, judging from the size of the branches, that of the colonies was moderately large, probably more than 15 cm. tall. Fragments of branches are as much as 5.5 cm. long. The cross section of the branches is subcircular, about 12 mm. is a common diameter, but some branches are

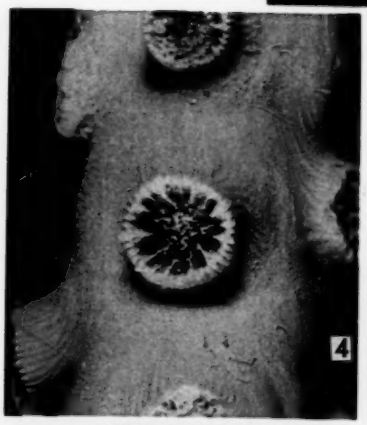
EXPLANATION OF PLATE 40

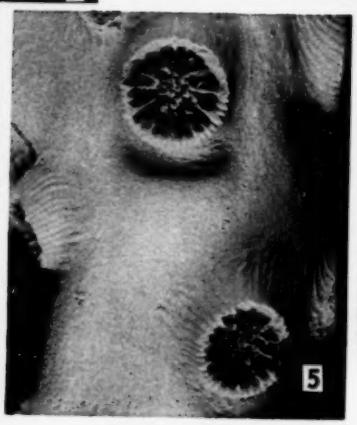
FIGS. *1–4—Carophyllia alaskensis* Vaughan, n. sp. *1, 2*, Side view and calice of the same specimen; *3, 4*, side view and calice of another specimen. Each view ×3. Specimens from *Albatross* station 4231. (p. 280)

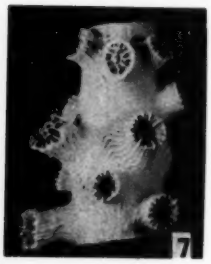
5–11—Archohelia vernonensis Vaughan, n. sp. *5, 6, 8, 10, 11*, Views of five specimens, natural size; *7*, calices, ×5, of specimen represented by *6; 9*, calices, ×5, of specimen represented by *8*. (p. 282)

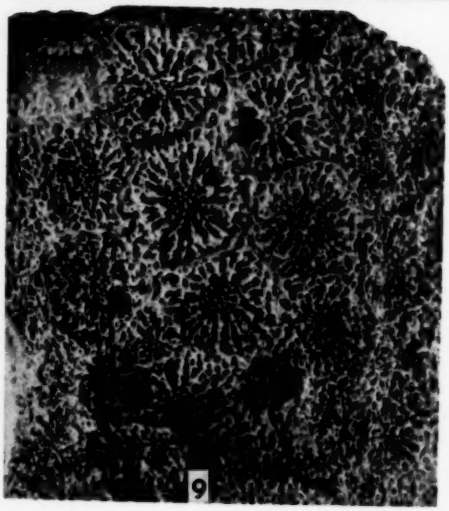


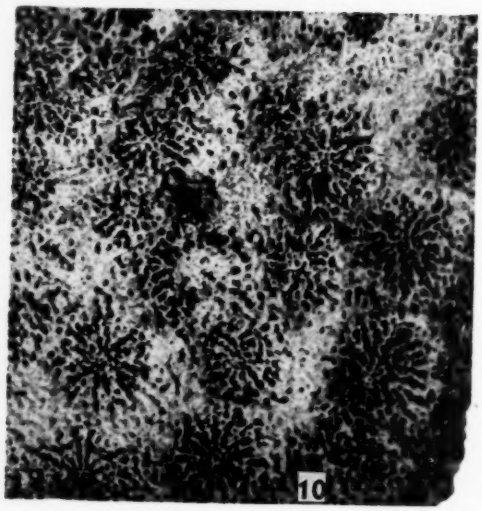
Vaughan, Recent and Eocene Corals











Vaughan, Eocene Corals

as small as 5.5 mm. in diameter, as shown by pl. 40, fig. 5. The size and shape of tips of the branches are partly controlled by the size of the axial corallite, the diameter of which is about 3.5 mm. Some tips are obtuse, 7 mm. in diameter; others are 5.5 mm. in diameter.

There is an axial corallite as noted above; the other corallites are arranged in ascending spirals. The diameter of the calices ranges from 2 to 3 mm. on specimen represented by pl. 40, fig. 5. Calices on other specimens are as much as 4 mm. in diameter. The distance between calices usually exceeds the calicular diameter. The margins of most calices are slightly elevated vertical to the coenenchymal surface, with low, flat or acute, equal costae corresponding to all septa. Some corallites have rather swollen bases, with the calicular apertures directed obliquely toward the end of the branch (pl. 40, fig. 10). Both kinds of calices occur on the same specimen.

There are normally three cycles of septa: the primaries are the largest, fusing by their inner ends to the lax, false columella; the secondaries are about half as long as the primaries, they do not reach the columella, nor do they fuse to the sides of the primaries; the tertiaries are small, rudimentary in many calices. Septal margins are finely dentate. The top of the columella is depressed, and in many corallites it is surrounded by the vertical inner edges of the primary septa. No dissepiments were observed.

The coenchyma is very dense. Most of its outer surface is marked by low sinuous costae, especially near the calices, and there are some fine granulations.

Comparisons.—The species that most closely resembles *Archohelia vernonensis* is *A. vicksburgensis* (Conrad) Vaughan (Vaughan, 1900, pp. 116–118, pl. 10, figs. 4–10). Of the figures referred to, see especially pl. 10, figs. 8 and 8*a*. The external features are very similar, but the septa are different. In *A. vicksburgensis* about one-half of the septa reach the columella, and there are on the inner ends of these septa paliform teeth. In *A. vernonensis* only six septa, those of the first cycle, reach the columella, and paliform teeth are weakly or not at all developed.

Species of corals and mollusks associated with Archohelia vernonensis

Names	U.S.G.S. locality numbers		
	14725	14726*a*	14726*b*
Corals			
Flabellum cuneiforme Lonsdale	×	×	×
Archohelia vernonensis Vaughan	×	×	×
Endopachys maclurii var. *tenue* Vaughan	×	×	×
Dendrophyllia sp., bases of specimens	×	×	×
Mollusks, identified by Julia A. Gardner			
Nucula mauricensis Harris	×		
Calorhadia (*Litorhadia*) sp.	×		
Barbatia (*Anadara*) sp. cf. *B.* (*A.*) *rhomboidella* Lea	×		
Chlamys wautubbeana Dall	×		
Venericardia planicosta Lamarck, s.l.	×		
Nemocardium sp. ind.	×		
Corbula (*Varicorbula*) sp. cf. *C.* (*V.*) *fossata* Meyer and Aldrich	×		
Dentalium (*Antalis*) *thalloides* Conrad	×		

Syntypes.—U. S. Nat. Mus. 547346 (figured), 547347.

Localities.—Hazard locality no. 1, U. S. Geol. Survey locality 14725; approximate

EXPLANATION OF PLATE 41

FIGS. *1–7*—*Archohelia gardnerae* Vaughan, n. sp. *1, 2, 3, 6*, Views of four specimens, natural size; *4, 5*, calices, ×5, of specimen represented by *4* (upper end of branch down); *7*, general view, ×2, of another specimen. (p. 281)

8–10—*Goniopora aldrichi* Vaughan. *8*, General view, natural size; *9, 10*, calices of the same specimen, ×4. (p. 284)

center of NW¼ sec. 6, T. 3 N., R. 11 W., east bank of Toro Bayou, Vernon Parish, La., submitted by Roy T. Hazzard. Hazzard locality 2, U. S. Geol. Survey locality 14726*a*; approximate center of north line SW¼ sec. 6, T. 3 N., R. 11 W., east bank of Toro Bayou, Vernon Parish, La. Hazzard locality 2, U. S. Geol. Survey locality no. 14726*b*, the same as the foregoing.

Mr. E. L. Fipps also collected *A. vernonensis* at the same locality.

Associated species.—The table shows the associated species.

Geological horizon.—Most of the corals other than the species of *Archohelia* and the mollusks are contained in cemented, indurated pieces of rock. Are these specimens really in place? Although the corals are not very well preserved, the faunal facies is that of the St. Maurice formation in Louisiana. Doctor Gardner refers the mollusks to the Lower Claiborne, Lisbon formation or equivalent beds. If the specimens of the associated species of corals and mollusks are in place, the horizon of *Archohelia vernonensis* is lower Claiborne. As has been pointed out, *A. vernonensis* differs in significant details from *A. vicksburgensis*.

Genus GONIOPORA de Blainville, 1830

GONIOPORA ALDRICHI

Vaughan, n. sp.

Plate 41, figures 8–10

The holotype is a single piece of a branch, which is swollen at both ends. The total length is about 51 mm.; diameter of lower end, about 26 mm.; diameter of upper end, 17.5 by 23 mm.; diameter between the swellings, 17 by 29 mm. The form of the specimen is illustrated by pl. 41, fig. 8.

Calices polygonal, large, and shallow. Range in diameter, from 3.4 to 6 mm., usual diameter, about 4.5 mm.; depth, about 1 mm. or even less. As a rule adjacent calices are separated by distinct, slightly raised, nearly continuous walls, but in places intercorallite reticulum is present, and it may measure as much as 2.5 mm. across. The radial elements in the reticulum are thick and sinuous.

The number of completely developed septa is normally 24, with the typical goniporid arrangement. Near the wall the outer ends may bifurcate, or short radial processes may be present between the outer ends of the septa. There is a circle of granules slightly detached from the wall, and the septal margins are slightly excavated between it and the wall. There are from two to four granules between the outer circle and the columella tangle. There are no paliform lobes.

Columella tangle well developed, reticulate, spongy; its upper surface, slightly depressed, flattish, and in the best-preserved calices finely papillate. It occupies about one-third of the calicular cavity.

Locality and geological horizon.—Cave Branch, 6 miles east of Thomasville, Ala.; Bashi marl (Woods Bluff horizon); collected by T. H. Aldrich.

Holotype.—U. S. Nat. Mus. 547345.

Remarks.—This is the only lower Eocene species of *Goniopora* so far discovered in America. Although the generic characters are typical, there are no known closely similar species. The species is named for Hon. T. H. Aldrich, who in years gone by did much to increase knowledge of the older Tertiary faunas of the southeastern United States.

REFERENCES

MARENZELLER, EMIL VON, *1904*, Stein- und Hydro-Korallen: *Harvard College, Mus. Comp. Zoology, Bull.*, vol. 43, pp. 75–87, pls. 1–3.

VAUGHAN, T. WAYLAND, *1900*, The Eocene and lower Oligocene coral faunas of the United States, with descriptions of a few doubtfully Cretaceous species: *U. S. Geol. Survey, Mon.* 39, 263 pp., 24 pls.

——, in ARNOLD, RALPH, *1903*, The paleontology and stratigraphy of the marine Pliocene and Pleistocene of San Pedro, Calif.: *California Acad. Sci., Me[illegible]* vol. 3, pp. 86–90.

MANUSCRIPT RECEIVED BY THE EDITOR OCTOBER 25, 1940.

JOURNAL OF PALEONTOLOGY, VOL. 15, NO. 3, PP. 285–304, PLS. 42–44, MAY, 1941

LOWER CRETACEOUS ROCKY MOUNTAIN NONMARINE MICROFOSSILS

RAYMOND E. PECK
University of Missouri, Columbia, Mo.

ABSTRACT—Charophyte oogonia and ostracods from formations of Lower Cretaceous age of the Rocky Mountain region are described and illustrated. The charophyte genera *Atopochara* Peck, heretofore known only from the Trinity of Texas and Oklahoma, *Clavator* Reid and Groves, and *Perimneste* Harris, heretofore known only from the Purbeck of England, are common in strata of Lower Cretaceous age in the Rocky Mountain region. The Ostracoda consist mostly of representatives of the fresh-water genera *Cypridea* Bosquet and *Metacypris* G. S. Brady. Two of the ostracod species occur also in the Trinity of Texas and Arkansas, and the entire ostracod fauna bears a close resemblance to Upper Purbeck-Wealden of England. The absence of known Lower Cretaceous microfossils in the Morrison is considered good evidence of the Jurassic age of the Morrison formation.

THIS STUDY was undertaken to determine the value of microfossils in establishing the age and relationships of continental Mesozoic and Tertiary formations in the Rocky Mountain area. A grant from the Penrose Fund of the Geological Society of America made it possible for me to spend ten weeks in Colorado, Utah, Idaho, Wyoming, and Montana in the summer of 1938, collecting samples from calcareous shales and shale partings in limestones. Over 200 samples were collected from formations ranging in age from Morrison (Jurassic) to Bridger (Eocene). Nearly half of the samples contained abundant and characteristic ostracods and charophyte oogonia. Excellent collections were obtained from widespread Morrison localities; in western Wyoming and eastern Idaho from the Lower Cretaceous Gannett group and the overlying black shales and thin limestones, here called the lower Bear River formation; from the Cretaceous Bear River formation of southwestern Wyoming; from the Flagstaff limestone in central Utah; from the Evanston formation of Hoback canyon, Lincoln County, Wyoming; and from the Green River and Bridger formations of southern Wyoming and Colorado. Small collections were obtained from the Lance formation of eastern Montana.

Preliminary examination of the collections obtained indicated that those from the Lower Cretaceous strata of western Wyoming, eastern Idaho and central Montana (Draney, Peterson, lower Bear River, and Kootenai formations) were the most interesting and probably of greatest stratigraphic value. A grant from the Research Council of the University of Missouri enabled me to spend August of 1939 making detailed collections from these formations. Mr. W. W. Rubey of the United States Geological Survey, who has spent several summers doing detailed geology of the area in western Wyoming, accompanied me during part of this month. His advice and aid in identifying outcrops in an area of complicated structure was invaluable and contributed much to the usefulness of this paper.

Mr. George Moore of Harvard Graduate School collected several samples in the Irwin quadrangle, where he was an assistant in a U. S. Geological Survey party. Dr. R. W. Harris of the University of Oklahoma loaned me the types of Vanderpool's Trinity ostracods for comparison and study. Dr. Frank Lozo of Texas Christian University and Mr. R. H. Schweers of Fort Worth, Texas, sent Trinity microfossils.

Mrs. Vaona Hedrick Peck retouched the photographs and prepared the plates.

STRATIGRAPHY

Mansfield and Roundy (1916) named the Gannett group and tentatively assigned it to the Lower Cretaceous. The outcrop is in a small area in Bannock County, Idaho, and Lincoln County, Wyoming, and extends north of Lincoln County across Snake River. The group is divided into five formations named, in descending order, the Tygee sand-

stone, the Draney limestone, the Bechler conglomerate, the Peterson limestone, and the Ephraim conglomerate. The Gannett group overlies the Jurassic Stump sandstone. As the sandstones and conglomerates were not considered promising as a source of microfossils, the collecting was confined to the Peterson and Draney limestones. Each of these formations was carefully sampled at or near the type locality and at most available exposures throughout the area of outcrop. Almost all the Draney samples were productive of both ostracods and charophytes. Most of the Peterson samples yielded charophytes, but only a few were productive of ostracods. The charophyte genera and species are, for the most part, common to both formations, but the ostracods are distinctive (see distribution table).

Overlying the Gannett group is a black shale and thin limestone series indistinguishable lithologically from the Upper Cretaceous Bear River formation. It has been mapped by the United States Geological Survey as Bear River, although it is recognized by the Survey that the lower part of the formation contains a fauna comparable to the Kootenai and Cloverly formations.[1] Samples obtained from shales associated with the thin limestones indicate that this series contains microfossils more closely related to those of the Gannett group than those of the Bear River of southwestern Wyoming. This series is here called lower Bear River.

The Kootenai formation of central Montana consists of a series of red, gray, and green sandstones and shales, a few lenticular beds of limestone, and a workable coal bed. It has yielded large collections of plant fossils and a few poorly preserved fresh-water invertebrates (Fisher, 1909, pp. 34, 35). In southwestern Montana the Kootenai consists of conglomerate, maroon, green, and yellow sandy shale, and buff sandstone, succeeded by a thick series of limestones (Richards and Pardee, 1925). Some of the limestones contain many gastropods. The Kootenai has generally been assigned to the Lower Cretaceous. Samples were obtained at a number of Kootenai limestone localities, most of which yielded microfossils.

[1] Rubey, W. W., oral communication.

CONCLUSIONS

There is a striking similarity between the microfossils of the Gannett and Kootenai and those of the Purbeck and Wealden of England as described by Harris (1939) and Jones (1885). The charophyte genera *Perimneste* Harris and *Clavator* Reid and Groves, heretofore known only from the Purbeck of England, are present in the Gannett and Kootenai, and representatives of *Clavator* are abundant. The ostracod genera are the same, and many of the Gannett and Kootenai species so closely resemble those of the Purbeck and Wealden that it is questionable as to whether they should be distinguished as species or varieties.

The microfossils from the Gannett, Kootenai, and lower Bear River are similar to those of parts of the Trinity group of Texas. The distinctive *Atopochara trivolvis* Peck, originally described from well samples identified as probably Glen Rose age, is abundant and characteristic in the Gannett, Kootenai, and lower Bear River. The genera *Clavator* and *Perimneste* are present in the Trinity. Various authors have noted the abundance of charophyte oogonia in the Trinity of Texas (Adkins, 1932, p. 318) and adjoining states, but I have had the opportunity of examining only small collections, most of them from well cuttings. Two of the ostracod species described by Vanderpool (1928) from the De Queen and Glen Rose formations occur also in the Draney and Kootenai formations.

It is significant that the three distinctive charophyte genera *Atopochara*, *Clavator*, and *Perimneste*, have not been recognized anywhere in the Morrison formation, nor do they occur in the Bear River Cretaceous formation of southwestern Wyoming. Samples collected systematically from the Bear River at two of the most fossiliferous localities near Evanston, Uinta County, Wyoming, though yielding many charophytes and ostracods, contained only one charophyte species common to the Gannett, Kootenai, lower Bear River, and the true Bear River. Some of the species described from the Bear River by Jones (1893) occur in the Draney, but at the time Jones wrote his paper the Gannett group was considered part of the Bear River.

Though samples were collected from the Morrison over most of Colorado, Wyoming, Montana, and in the Black Hills of South Dakota, the only species found common to the Morrison and the Gannett group are the somewhat indeterminate *Cypris purbeckensis* Forbes? and *Chara voluta* Peck. The of *Cypridea* and *Metacypris* in association with *Atophochara trivolvis* Peck, heretofore known only from the Trinity of Oklahoma and Texas, substantiates the conclusions of most students that the Gannett group and the upper part of the Kootenai formation are Lower Cretaceous in age.

Draney, Peterson, Kootenai, and lower Bear River Charophyta and Ostracoda

Species \ Formation	Upper Cretaceous	Lower Cretaceous					Jurassic
	Bear River formation	L. Bear River formation	Draney formation	Peterson formation	Kootenai formation	Trinity group	Morrison formation
CHAROPHYTA							
Aclistochara cylindrica		×	×				
A. mundula	×	×	×	×	×		
Atopochara trivolvis		×	×	×	×	×	
Chara voluta			×				×
Clavator harrisi		×	×	×	×	×	
Perimneste corrugata				×		×	
OSTRACODA							
Candona sp. indet.			×				
Cypridea anomala		×	×		×		
C. brevicornis			×				
C. compta		×	×				
C. diminuta			×			×	
C. inornata					×		
C. longispina					×		
C. nitidula		×	×				
C. wyomingensis			×		×	×	
Cypris purbeckensis?			×				
Metacypris angularis				×	×		
M. persulcata		×					

charophyte genera *Atopochara*, *Clavator*, and *Perimneste* and the highly ornamented species of *Cypridea* and *Metacypris*, described in this paper, have not been found in the Morrison. The Morrison microfossils described by Harper and Sutton (1935) and Peck (1937) are widespread in the Morrison and are an easily determined assemblage. The Kootenai overlies the Morrison in central Montana, and each contains characteristic microfossils. The absence of the charophyte genera *Clavator* and *Perimneste* and of the highly ornamented species of *Cypridea* and *Metacypris*, all found in the Purbeck of England of known Jurassic age (Arkell, 1933, p. 545), indicates that the Morrison is Jurassic and probably older than Purbeck.

The occurrence of the genera *Clavator*, *Perimneste*, and highly ornamented species

COLLECTION LOCALITIES

Lower Bear River formation.—1. A discontinuous outcrop of carbonaceous shales and thin limestones along the road on the east side of Grey's River valley, 1.4 miles northwest of Young's Ranch, Lincoln County, Wyoming. This outcrop is Bear River.

2. Carbonaceous shales and impure fossiliferous limestones on the north side of the road in Tincup Creek canyon, 1.7 miles east of the mouth of South Fork of Tincup Creek in T. 5 S., R. 45 E., Freedom quadrangle, Idaho-Wyoming. This series is above the Draney and is lithologically similar to the true Bear River. However, it carries a microfossil assemblage more nearly related to the Draney than to the Bear River, and Dr. J. B. Reeside, Jr. has determined the larger fossils to be Cloverly-Kootenai in age.

3. Road cut in carbonaceous shales and thin limestones about one-fourth mile east of Smith's Fork Ranger Station on Smith's Fork of Bear River, Lincoln County, Wyoming.

3a. Draney and lower Bear River formations

on the north side of Thomas Fork Creek in the N ½ sec. 26, T. 28 N., R. 119 W., Cokeville quadrangle, Lincoln County, Wyoming.

Gannett group.—4. Shales in and near the Peterson limestone on the south side of the road in Tincup Creek canyon 1.7 miles west of Freedom School, T. 5 S., R. 46 E. Freedom quadrangle, Idaho-Wyoming.

5. Shales in the Draney limestone on the north side of the road in Tincup Creek canyon about ½ mile east of the mouth of South Fork of Tincup Creek, Freedom quadrangle, Idaho-Wyoming.

6. Carbonaceous shales and limestone, probably Draney, ½ mile west of the mouth of South Fork of Tincup Creek, north side of the road, Freedom quadrangle, Idaho-Wyoming.

7. Limestone and shale series, dipping west, exposed along the road in Tincup Creek canyon at the extreme western edge of R. 45 E., in T. 5 S., Freedom quadrangle, Idaho-Wyoming. Probably Draney limestone.

8. White limestone and shale series, probably Peterson, on Tincup Creek canyon road, 3.8 miles west of the mouth of the South Fork of Tincup Creek, Freedom quadrangle, Idaho-Wyoming.

9. Draney limestones and shales, type locality, on the divide east of the Draney ranch in T. 8 S., R. 46 E., just west of the Idaho-Wyoming line in the north part of Crow Creek quadrangle, Idaho-Wyoming. Samples were taken at intervals throughout the section and most of them were productive. There was no marked change in microfossils from the bottom to the top of the section.

10. Peterson limestones and shales on the south side of Stump Creek where it cuts across Spring Creek syncline in T. 7 S., R. 46 E., Freedom quadrangle, Idaho-Wyoming. This locality is less than a mile north of the type locality, and the outcrop is continuous with that of the type locality.

11. Black dense limestone and shale series, 4.5 miles west of Snider Basin Ranger Station in a cut on a road branching north from the Landers Cutoff, Lincoln County, Wyoming. The limestone weathers white. According to W. W. Rubey (oral communication) the Draney and Peterson have thinned to one lithologic unit in this area.

12. Peterson limestones and shales along Landers Cutoff, 1.2 miles east of Smith's Fork Ranger Station, Lincoln County, Wyoming.

13. Draney limestone and shale series 2.5 miles northwest of Smith's Fork Ranger Station along Landers Cutoff road, Lincoln County, Wyoming.

14. Draney limestones and shales along the Montpelier-Afton Highway in SE ¼ NE ¼ sec. 24, T. 29 N. R. 119 W., Lincoln County, Wyoming.

15. Draney limestone and shale in highway cut on Montpelier-Afton Highway near the east center of the W ½ sec. 8, T. 29 N., R 118 W., Lincoln County, Wyoming.

16. Limestone and shale series underlying the Bear River on the north side of Snake River canyon between Alpine and Wilson, Wyoming. The sample was taken 11 miles east of Alpine. According to W. W. Rubey (oral communication) the Draney and Peterson have thinned to one lithologic unit at this locality. The Bear River at this locality was not productive.

17. Draney limestone and shale—the base of the limestone about 180 feet below the top of the Draney in the NW ¼ sec. 9, T. 3 S., R. 45 E., on McCoy Creek, Irwin quadrangle, Idaho. Collected by George Moore.

18. Shale parting between two resistant limestones 5 feet above the base of the Draney in SE ¼ sec. 16, T. 3 S., R. 45 E. on the north bank of McCoy Creek in Irwin quadrangle, Idaho. Collected by George Moore.

19. Draney limestone and shale 125 feet above the base on Old Baldy Peak in NE ¼ sec. 31, T. 3 S., R. 45 E., Irwin quadrangle, Idaho. Collected by George Moore.

20. At the base of the Bechler on top of the Peterson limestone in the bank of McCoy Creek in the SE ¼ sec. 16, T. 3 S., R. 45 E., Irwin quadrangle, Idaho. Collected by George Moore.

21. Draney limestone about 150 feet above the base. Along the trail to Black Mountain in SE ¼ sec. 18, T. 3 S., R. 46 E., Irwin quadrangle, Idaho. Collected by George Moore.

Kootenai formation.—22. Under a 2-foot bed of dark, dense, fossiliferous, lenticular limestone weathering brown in the upper part of the formation on the north side of a tributary to Belt Creek in sec. 18, T. 19 N., R. 6 E., about 1 mile northeast of Belt, Montana.

23. Shales around a nodular limestone underlain by red clay along the road 1 mile southwest of Griffin, about 14 miles southeast of Great Falls, Montana, in T. 18 N., R. 4 E. The sample contained vegetative parts of *Clavator* Reid and Groves.

24. Limestone and red clay and shale series on north side of U. S. Highway No. 10, one mile west of Drummond, Montana. Samples taken in thick limestones near the top of the exposure.

25. Near a nodular limestone in green shales underlying red shales in road cut on U. S. Highway No. 10, 10 miles east of Whitehall, Montana.

26. A thick fossiliferous limestone and gray shale series in the Upper Kootenai south of the Bighole River along the high road between Twin Bridges and Dillon, Montana, in NW ¼ sec. 11, T. 5 S., R. 8 W.

27. A series of samples taken near fossiliferous limestones exposed in a small anticline 8 miles east and 3 miles north of Drummond, Montana. The exposures were sampled along a road leading north from U. S. Highway No. 10.

SYSTEMATIC DESCRIPTIONS

CHAROPHYTA

Family CHARACEAE

Genus CHARA Vaillant, 1719

Chara is a modern genus, well established and widely distributed. Many persons working with the fossil oogonia, the only part of the plant commonly preserved in a recognizable state, have hesitated to use the name, inasmuch as it cannot be proved that

the oogonia fulfill all the required characters of the modern genus.

Pia (1927) stated that it was extremely unlikely that all the fossil oogonia should belong to the modern genus *Chara* and proposed that the form-genus name *Gyrogonites* Lamarck be used for all fossil oogonia with doubtful affinities but with five sinistral spiralled units. Pia's procedure was followed by Peck (1934) in describing oogonia from the late Paleozoic and early Mesozoic. Other authors working with regular oogonia with five sinistral spirals have used the name *Chara*, explaining that, though it could not be proved that the fossils belonged to this genus, neither could it be proved that they didn't.

It is certainly true that the exact systematic position of these oogonia cannot be determined. Then it follows that any division used will be, in part at least, a form genus. The term *Gyrogonites* is not well known. Its generic limitations are not established, and references in the literature are scarce. None of these objections is valid for rejecting a generic name. The term "gyrogonite" has recently been used by Harris (1939) for the calcified body commonly called the oogonium. It seems better to use the established name *Chara* for all spiralled oogonia that cannot be distinguished from modern forms and to propose new generic names for oogonia that differ from modern charophyte oogonia in some constant and recognizable characters.

CHARA VOLUTA Peck
Plate 42, figures 12–14

Chara voluta PECK, *1937*, Jour. Paleontology, vol. 11, p. 85, pl. 14, figs. 16–19.

The outstanding character of this species is the small size. Only two other species have oogonia averaging less than 0.4 mm. in length. They are *Clavator grovesi* Harris and *Clavator bradleyi* Harris, both from the Purbeck beds of England. *C. voluta* falls well within the upper limit prescribed for *Clavator grovesi* and within the lower limit established for *Clavator bradleyi* (Harris, 1939, p. 71), and it is impossible to establish standards by which it may be differentiated from either of these species at present. *Clavator grovesi* and *Clavator bradleyi* are represented by vegetative parts as well as oogonia. On both species the oogonia are covered by a utricle, but the oogonia are often preserved in isolation (Harris, 1939, p. 72). *Chara voluta* was originally described from three specimens from the Morrison formation but has since been collected from several localities in the Morrison and from two localities in the Draney formation. In the Draney formation it is associated with *Atopochara trivolvis* Peck and *Clavator harrisi*, n. sp., both species with utricles covering the oogonia. No evidence of a utricle has been observed on oogonia referred to *C. voluta*.

Occurrence.—Morrison formation, a light green shale in the lower part of the formation about 18 miles northwest of Rawlins, Wyoming; near a thin limestone in the upper part of the Morrison on the north side of Middle Fork of the Popo Agie River southwest of Lander, Fremont County, Wyoming; 8 miles north of Canon City, Colorado, near a limestone below the varicolored beds containing the old dinosaur quarry; in shales associated with the Draney limestone, localities 5 and 6.

Types.—Univ. Missouri, holotype, 31011-5; paratypes, 31013-5; and figured specimens, 31015-2, 31015-3.

CHARA sp.
Plate 42, figure 40

Four small oogonia collected from the Kootenai formation probably represent a new species. They are smaller than the average oogonia but larger than those referred to *Chara voluta* Peck. They have an average length of about 0.46 mm. and an average width of 0.4 mm. The enveloping cells were filled evenly with calcite, and the oogonia are exceptionally smooth. Species represented by oogonia only are difficult to define, and I prefer not to erect new species on so few specimens. The illustration and discussion are included for sake of completeness.

Occurrence.—Kootenai formation, locality 25.

Figured specimens.—Univ. Missouri 31015–4.

Family CLAVATORACEAE Pia
Genus ATOPOCHARA
Peck, 1938, emend.

Small globular bodies about 1 mm. in diameter, on which is developed a three-rayed

symmetry. Each ray consists of three vertical units originating at or near the basal opening and ascending to or near the equatorial plane; five small units grouped on or near the equatorial plane; and four sinistrally spiralled units extending from slightly above the equatorial plane to or near the summit opening. These 36 units comprise a utricle surrounding and closely adhering to a regular five-spiralled charophyte oogonium.

Genotype, *Atopochara trivolvis* Peck, Trinity of Oklahoma.

Remarks.—The genus *Atopochara* was originally based upon 25 specimens collected from four wells in Texas and Oklahoma. The genus is abundantly represented in the Gannett and Kootenai formations, and a study of this additional material has modified my interpretation of the genus. The utricle adheres closely and seldom, if ever, breaks away to expose the oogonium. On a few specimens the utricle and oogonium are both broken away, and faint spiral markings are present on the internal mold (pl. 42, fig. 5). These few specimens with spiral markings and the association of *Atopochara* with undoubted representatives of the Clavatoraceae indicates that it belongs to that family and is, as suggested by Harris (1939, p. 73) "one of the most advanced of the Clavatoraceae in fruit structure."

Atopochara trivolvis Peck
Plate 42, figures 1–6

Atopochara trivolvis Peck, *1938*, Jour. Paleontology, vol. 12, p. 174, pl. 28, figs. 8–12.

Atopochara trivolvis is widely distributed in Lower Cretaceous fresh-water deposits of North America. The species was originally described from a probable clastic facies of the Glen Rose formation of Texas and Oklahoma; it is abundant in the Peterson and Draney limestones and associated shales of the Gannett formation of western Wyoming and eastern Idaho and in limestones and calcareous shales of the Kootenai formation of central Montana; and it is fairly common in the limestones associated with the lower Bear River black shales above the Gannett.

Remarks.—Among the hundreds of well-preserved specimens available for study, the only noticeable variations are in size and shape. A few specimens from the Kootenai and Gannett are smaller than those originally described, and some of them have a shorter and wider base, giving the individual a shape more pyriform than globular. Neither of these variations is consistent.

The species is widely distributed, easily recognized, usually well-preserved, and is probably confined to strata of Lower Cretaceous age.

Occurrence.—Present in all Peterson and Draney localities; in lower Bear River localities 2 and 3; in all Kootenai localities except 25.

Types.—Univ. Missouri, holotype, 31014-2; paratypes, 31014-3; figured specimens, 31014-4, 31014-5, 31015-1.

Genus Aclistochara
Peck, 1937, emend.

Charophyte oogonia composed of five sinistrally spiralled units with five calcified coronula cells resting on their distal extremities or, in the absence of coronula cells, indentations showing their former presence.

Genotype, *Aclistochara bransoni* Peck, Morrison formation of Wyoming.

Remarks.—In studying an assemblage of oogonia from the Morrison formation several years ago it was found that certain species constantly possessed a truncated summit, usually with a large opening. On a few of the better-preserved specimens, five small indentations were found near or on the summit, which were interpreted as probably marking the presence of coronula cells that must have partially calcified. It was prophesied that specimens with unquestioned coronula cells preserved would probably be discovered sometime (Peck 1937, p. 87). The genus was defined, however, as having an open summit as its chief generic character. It was recognized that many of the regular oogonia referred to the genus *Chara* failed to calcify as completely near the summit as in other places, and that the weaker part was often broken away, thus creating some confusion and an element of doubt in identifying genera. But the flattened summit was so consistent within certain species that it seemed of unquestionable diagnostic value, especially when large collections were considered.

Harris (1939, p. 77) briefly reviews the genus *Aclistochara* in connection with his

examination of 500 specimens of the modern *Chara vulgaris* and the Purbeck *Clavator grovesi*. None of the oogonia of *Chara vulgaris* possessed an open summit, but Harris states (p. 78) "that in *C. grovesi* the hole, which is undoubtedly due to breakage along a line of weakness, is sometimes just as regular as in Peck's *Aclistochara* species." He concludes that "this then would also appear to be a feature which is not fully reliable, but yet of a certain diagnostic value."

Since the proposal of the genus *Aclistochara* in 1937 I have had the opportunity of examining large collections of oogonia from the Morrison, Gannett, Kootenai, Bear River, Wasatch, Lance, and Evanston formations, ranging in age from the Jurassic to Tertiary. Most of the various species are represented by hundreds of specimens. It is found that on many of these excellently preserved specimens there is a consistently open summit, or the "lime-shell" becomes very thin at the summit, and small indentations indicate the presence of former coronula cells. On one undescribed species from the Evanston many specimens have coronula cells in place.

On isolated specimens it would be difficult to differentiate the representatives of the genus *Aclistochara* from specimens of *Chara* on which the summit was broken or had failed to calcify to the extent of the rest of the "lime-shell."

Aclistochara mundula
Peck, n. sp.
Plate 42, figures 7–11

Oogonia small, averaging about 0.5 mm. in length and 0.37 mm. in width, maximum width at or below midheight; urn-shaped, with obtusely rounded bases and conspicuously truncated summits. Spiral ridges commonly intercellular, sharp and narrow, rarely cellular and flush. Equatorial angle usually 10° or less, a few between 10° and 15°, rarely as high as 18°. Summit opening comparatively large and generally giving the appearance that spirals end at the margin, but well-preserved specimens show that spirals continue to the center of the opening, with the summit depressed for reception of coronula cells. No coronula cells preserved. Eleven or 12 spirals visible in a lateral view.

Remarks.—The above description is based on a study of more than 500 specimens. The urn shape, low equatorial angle, and conspicuously truncated summit make it an easily recognizable species.

A. mundula is abundant and long-ranged. Almost every sample collected from the Bear River, Gannett, and Kootenai formations that was at all productive yielded many representatives of this species. The specimens are remarkably uniform, but, as would be expected among so many specimens, there is some variation. Twenty-one specimens out of 500 possess cellular ridges. Only one of these is from the Bear River—the greater proportion of cellular-ridged forms were collected from the Gannett and Kootenai. This is possibly an environmental condition. The Bear River specimens are more typically urn-shaped, broadening rapidly above the base, narrowing rather rapidly above the equator to the short almost vertical neck. This form can be duplicated in the Kootenai and Gannett, but in these formations there is more of a tendency toward a cylindrical oogonium with a uniform diameter throughout most of the length. This variation is not sufficiently distinctive or constant for the differentiation of varieties or for use in zoning.

Occurrence.—Common throughout the Bear River, Draney, Peterson, and Kootenai formations.

Types.—Univ. Missouri, holotype, 31016-5; and paratypes, 31016-3, 31016-4.

Aclistochara cylindrica
Peck, n. sp.
Plate 42, figures 38, 39, 41–44

Oogonium elongate, cylindrical, with a pointed projecting base and flattened summit; of medium size, averaging 0.6 mm. in length, and 0.4 mm. in width. The minimum and maximum length measured on 100 specimens is 0.5 mm. and 0.7 mm., the minimum and maximum width 0.35 mm. and 0.43 mm,. respectively. Spiral ridges mostly cellular, broad, gently convex, a few intercellular with a median line of division, the calcification fairly complete on all specimens. Equatorial angle 15° to 20°, seven to 10 spirals visible in lateral view.

Remarks.—The description is based on a study of more than 100 specimens. Representatives of the species are consistent in

size, shape, length-width ratio, and amount of calcification of the spiral cells. Specimens collected from the Draney are a little larger and more completely calcified than those collected from the lower Bear River.

A. cylindrica agrees in several characteristics with various species of Morrison charophytes. *A. elongata* Peck is smaller and lacks the pointed base so characteristic of *A. cylindrica*. *A. obovata* Peck has the pointed base but is more ovate, has more spirals visible in a lateral view, a lower equatorial angle, and is smaller. *A. jonesi* Peck is smaller and has an obtusely rounded base. Some of these differentiating characters come well within the range of variation noted in the study of oogonia of modern *Chara vulgaris* by Harris (1939, p. 75), but it has been found through study of considerable numbers of each of these species that the variations are remarkably consistent and the species are easily recognizable.

Occurrence.—Draney formation and lower Bear River black shales. Localities 1, 5, and 6.

Types.—Univ. Missouri, holotype, 31015-5; and paratypes, 31016-1, 31016-2.

Genus Clavator Reid and Groves, emend. Harris, 1939

Genotype, *Clavator reidi* Groves, Purbeck Beds of England.

Representatives of the genus *Clavator* occur in considerable abundance in fresh-water limestones of the British Purbeck. The preservation is unusual in that the vegetative parts of the plants are preserved as calcite or replaced by silica. Ordinarily, on the death of a charophyte the calcified parts of the stems and leaves disintegrate into a fine-grained mud, and only the oogonia remain recognizable as of organic origin.

Vegetative parts referable to *Clavator* have not been definitely recorded outside the Purbeck beds, although Pia (1935) described some sections of vegetative and reproductive organs that Harris (p. 72) considers as possible representatives of *Clavator* from rocks of approximately Purbeck age in Switzerland. Vegetative parts of the plant are uncommon in North America, but oogonia with their distinctive utricles are quite common in fresh-water strata of Lower Cretaceous age.

Inasmuch as the vegetative parts constituted a considerable part of the material studied by Reid and Groves (1916) and Harris (1939), their generic descriptions and discussions dealt but little with characters of the oogonia or utricles. Harris (p. 15), in discussing the comparative morphology of the genus, lists the following as peculiarities of the oogonia:

> (a) The outer wall of the oogonium is calcified, as well as the inner. Its shape is slightly unusual. (b) The outer wall of the oogonium often shows conspicuous blunt knobs. (c) The oogonium is invested in a utricle.

The only particular in which the North American specimens agree with Harris' description is that the oogonia are invested in a utricle. However, the utricle is distinctive and agrees in many particulars with the descriptions and figures given by Harris for *C. reidi* Groves and *C. grovesi* Harris. The utricle on specimens of *C. grovesi* are well developed and are described by Harris (1939, p. 49) as follows:

> The utricle is nearly always well developed; unlike that of *C. reidi* it is always laterally compressed, that is to say it grows more above, below and beyond the oogonium than at the sides.
>
> The cells composing it form the following groups:
>
> (1) Usually a large basal cell runs from the leaf right up to the utricle apex as in *C. reidi*. Occasionally no such cell is recognizable.
>
> (2) On each side a set of about seven cells radiate from a point near the base of the oogonium. These cells normally cover the lateral and adaxial wall of the oogonium, though occasionally they fail to cover the adaxial surface. They normally extend up to the apex of the oogonium, though leaving a round hole where the oogonial apex is exposed. These lateral cells radiate from a point distinctly above the base of the oogonium, where a short cell growing out from the leaf ends. This is perhaps to be regarded as a peculiar "head cell." From this head cell a few small erect spines usually spring, but only the bases of these are calcified.
>
> In the majority of utricles the lateral cells meet along the distal and upper sides of the oogonium and project, forming a jagged crest. In a few, however, there are some small cells fitted in along the upper side which appear to be distal ends of spine cells from the node above, which have grown down to the oogonium.

Clavator harrisi Peck, n. sp.

Plate 42, figures 25–37

Oogonium small, averaging about 0.7

mm. in length and 0.57 mm. in width, ovoid, composed of five sinistrally spiralled units that make about two complete turns in their ascent and recurve distally to form a beak or projection about the summit opening. Calcification uniform and fairly complete, most specimens possessing a smooth and rounded exterior with unit divisions marked by small furrows.

Utricle well developed on most specimens, composed of four groups of long and short almost vertical units that completely or partly cover the oogonium and develop a bilateral symmetry. The groups are:

1, One fairly large deeply grooved unit that originates at the basal opening and ascends vertically with little or no change in size to or above the equator. This unit does not divide or give rise to other units. On a few specimens it reaches the summit, but usually near the equator it loses its identity in a roughened area of tubercles or by the joining of the lateral fan-shaped units (pl. 42, figs. 28, 34).

2, Adjacent groups on each side of unit 1 are large and usually exact duplicates, giving the utricle a compressed appearance and bilateral symmetry. Each group originates with a single small vertical unit at the basal opening. This unit ascends a short distance with units branching from each side, and below the equator of the specimen gives origin to a group of ten or eleven radiating furrows, which spread out fanwise to cover a considerable part of the oogonium. The radiating units terminate against unit 1 or against each other at the summit, and against unit 4 (pl. 42, figs. 25, 29).

3, Group 4 originates as a fairly large furrow at the basal opening, ascends vertically between the distal ends of the radiating groups to about the equator of the specimen and gives rise to four or five short radiating furrows that may themselves give rise to several more units near the summit. This unit is the least regular of the four. It appears to have developed last and to have developed to fill in any uncovered space between the large radiating units (pl. 42, fig. 31).

The bilateral symmetry is developed with reference to a plane bisecting units 1 and 4. The trilateral symmetry is nearly attained in that, on the globose specimens, unit 4 develops as nearly as possible on the plan of units 2 and 3.

Remarks.—*C. harrisi* is a widely distributed and easily recognized species. The spiralled oogonium is distinctive and easily recognized even when entirely divested of the enveloping utricle, a circumstance that rarely occurs. Ordinarily a part of the utricle, at least, is present to aid in the identification. Harris notes that the utricle is somewhat irregular in development on *C. reidi* and *C. grovesi*, but on most of his specimens of *C. grovesi* the utricle is complete and well preserved. On many of the specimens of *C. reidi* the utricle is absent or incomplete. Harris interprets this as being the result of differential development of the utricle on different specimens. On various specimens of *C. harrisi* the utricle may be absent, may partially enclose the spiralled oogonium, or may completely invest the spiralled form. On some specimens the utricle is present but is so thin that the spiralled units are easily visible through the utricle wall. In many cases this is evidently a result of the utricle failing to develop uniformly, in other examples part of the utricle has been broken off or worn away.

The utricle is somewhat irregular in form. The two large radiating groups of cells are almost always uniform and are well developed. Near the summit the furrows may grade out into tuberculated areas or may be absent. The single unit described as unit 1 is also fairly regular. Unit 4 is very variable. Where this unit is small and poorly developed the utricle is distinctly compressed. On globose specimens, it closely resembles the two large radiating units. The variations thus produced are not sufficiently consistent to constitute specific differences.

Vegetative parts probably belonging to the genus *Clavator* and presumably to *C. harrisi*, n. sp., are illustrated on pl. 42, figs. 35–37 from the Kootenai formation.

Occurrence.—Abundant in the Peterson and Draney limestones and associated shales and in limestones and associated shales of the Kootenai formation. Present in wells of Texas in the Trinity.

Specifically, the species was found to be abundant at all listed Gannett localities; present or abundant in all listed Kootenai localities except 25; present in lower Bear

River black shales localities 2 and 3; at a depth of 3385 to 3522 feet in the Morrow and Scarborough No. 1 well on the L. C. Fuller lease, Fannin County, Texas; at a depth of 2600 feet in the Texas and Pacific Coal and Oil Company well No. 1 on the W. W. Bogel lease, Presidio County, Texas; at a depth of 1500 feet in the Phillips No. 1 Midge well, Kimble County, Texas; and near the base of the Glen Rose at a depth of 780–825 feet in a greenish calcareous shale in the Humble S. E. Couch No. 1 well, D. & S. E. R. survey, sec. 3, Blk. 2 R, 1320 feet from north and west lines of section 3, Crockett County, Texas. I am indebted to Dr. Frank E. Lozo of Texas Christian University and the Production Division of the Gulf Oil Company for the privilege of studying the specimens from Fannin and Presidio Counties, Texas. Mr. R. W. Schweers presented the specimens from Crockett County, Texas.

Types.—Univ. Missouri, holotype, 31017-1; and paratypes, 31017-2, 31017-3, 31017-4, 31017-5, 31018-1.

Genus PERIMNESTE Harris, 1939

Genotype, *Perimneste horrida* Harris, Purbeck Beds of England.

This genus is identified in North America solely on the basis of calcified bodies resembling those identified by Harris as antheridia. Harris described the genus from materials collected from the middle and upper Purbeck beds of England, where the entire plant was preserved as silicified remains in limestone and chert. The main generic characters are based upon vegetative parts of the plant that have not been recognized in North America. Harris gave a brief description of the calcified antheridia and illustrated what appears to be either parts of the antheridial wall or external molds of the antheridial wall. These illustrations and de-

---

EXPLANATION OF PLATE 42

All figures ×28

All specimens in University of Missouri collections.

FIGS. *1–6—Atopochara trivolvis* Peck. *1*, Lateral view of large specimen showing division between rays, U.M. 31015-1. *2*, Lateral view of small individual, U.M. 31014-4. *3*, *4*, Basal and lateral views, U.M. 31014-5. *5*, *6*, Exfoliated specimen showing impression of spirals on internal mold and summit view of small individual, U.M. 31015-1. All specimens illustrated from the Draney formation. (p. 290)

7–11—Aclistochara mundula Peck, n. sp. *7*, *10*, *11*, Two lateral views and a summit view of Upper Cretaceous Bear River paratypes, U.M. 31016-3. *8*, Lateral view of holotype from Draney formation, U.M. 31016-5. *9*, Lateral view of small paratype from lower Bear River, U.M. 31016-4. (p. 291)

12–14—Chara voluta Peck. *12*, *13*, Lateral and summit views of two small specimens from the Draney formation, U.M. 31015-3. *14*, Lateral view of specimen from the Draney, U.M. 31015-2. (p. 289)

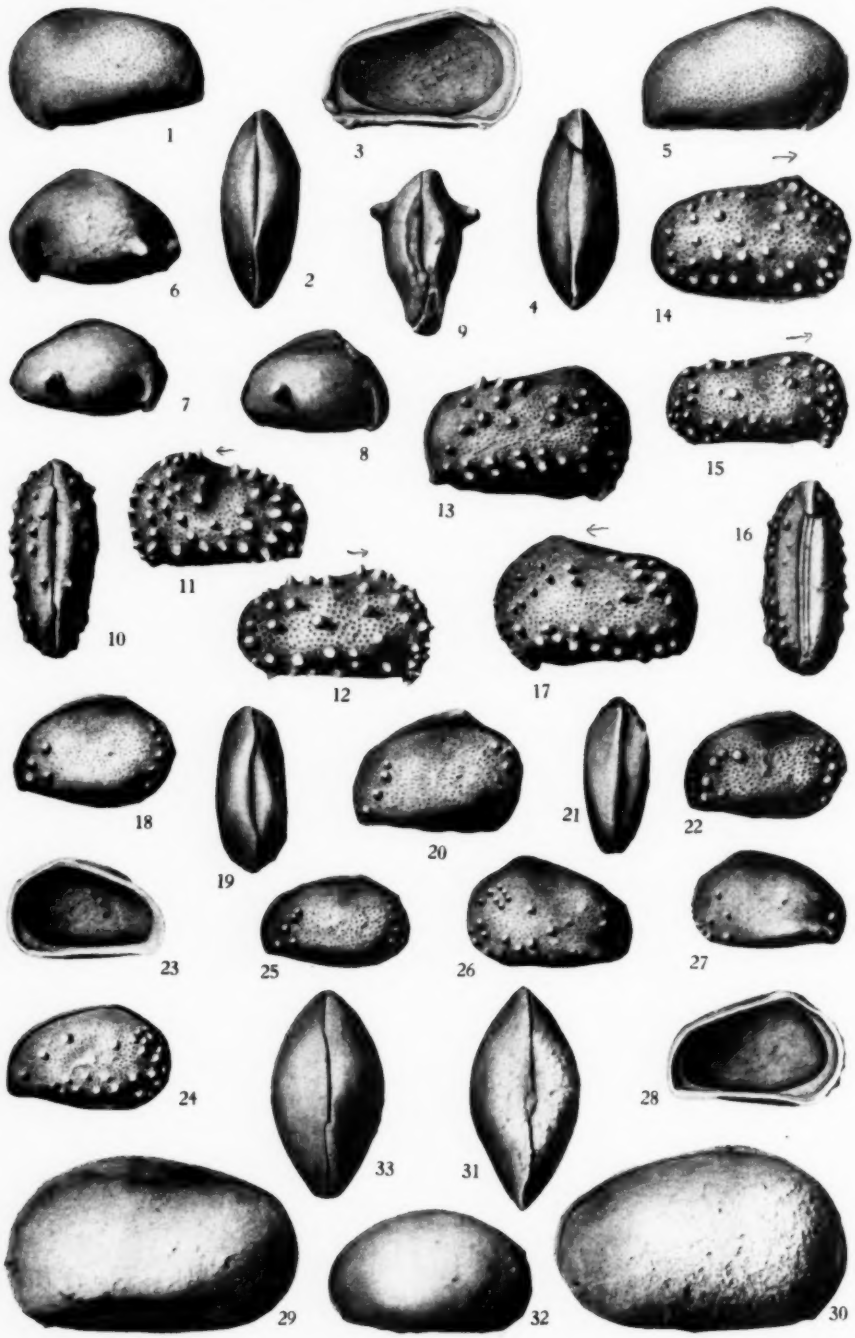
15–24—Perimneste corrugata Peck, n. sp. *15*, *17*, *21–23*, Paratypes, U.M. 31018-3; *15*, *22*, *23*, lateral views showing horizontal furrows, prominent equatorial opening on the left. *16*, Lateral view showing interfingering of vertical furrows—prominent equatorial opening on the right. *17*, Lateral view showing less prominent equatorial opening. *21*, End view. *18–20*, *24*, Lateral view looking into prominent equatorial opening, end view, and two side views of holotype, U.M. 31018-4. All specimens from the Peterson. (p. 295)

25–37—Clavator harrisi Peck, n. sp. *25*, Lateral view showing large radiating unit and, *30*, lateral view showing nodular appearance of paratype with thin utricle, U.M. 31018-2. *26*, *32*, Lateral view of paratypes showing appearance of oogonium (*26*) without utricle and with utricle partly exfoliated (*32*), U.M. 31017-4. *27*, *28*, Summit and lateral views of paratype—the lateral view of small unit showing junction of radiating cells of large units, U.M. 31017-2. *29*, Lateral view of paratype with well-developed large unit of radiating cells, U.M. 31017-3. *31*, Lateral view of holotype showing well developed unit 4, U.M. 31017-2. *33*, Basal view of paratype, U.M. 31017-2. *34*, Lateral view of paratype showing unit 1, U.M. 31017-5. *35–37*, Cross-section and longitudinal views of stems, U.M. 31018-1. All illustrations except *35–37* from the Draney. Vegetative parts from the Kootenai. (p. 292)

38, *39*, *41–44—Aclistochara cylindrica* Peck, n. sp. *38*, Lateral view of holotype from Draney, U.M. 31015-5. *39*, *41*, Lateral and summit views of paratypes from the Draney, U.M. 31016-2. *42*, Specimen with only four spirals. *43*, *44*, Summit and lateral views of paratypes from the lower Bear River formation, U.M. 31016-1. (p. 291)

40—Chara sp. indet. Lateral view of small specimen from the Kootenai, U.M. 31015-4. (p. 289)

Peck, Lower Cretaceous Charophyta



Peck, Lower Cretaceous Ostracoda

scriptions correspond so closely to the calcified bodies collected from the Peterson limestone and the Trinity of Texas that there seems little cause to doubt that they are the same thing.

By careful work and sectioning Harris has been able to associate the antheridia with oogonia of definite characters so that both bodies have been identified as belonging to the same species. In the collections studied in this work, where the specimens were obtained by washing shale samples and thus are unattached, it is impossible to associate the antheridia identified as *Perimneste* with any one set of oogonia. The most common associate of *Perimneste corrugata*, n. sp., is *Clavator harrisi*, n. sp., but Harris has identified both genera and associated them with vegetative parts in the Purbeck beds. Harris also states (p. 63) that the oogonia of *P. horrida* Harris are "surrounded by a considerable number of calcified leaf ramuli which, however, scarcely form anything definite enough to be termed a utricle." The utricle of *C. harrisi* is definite and ordinarily well preserved. Any one of the other oogonia occurring in the Gannett formation may be the oogonia of *Perimneste corrugata*, but I cannot discover any evidence that would point toward one more than the other. Harris states (p. 64) that many of the oogonia were found isolated. His illustrations of oogonia, called gyrogonites, closely resemble the oogonia described from the Morrison formation as *Aclistochara bransoni* Peck. The genus *Aclistochara* occurs in the Gannett formation, and one of the species referred to that genus may be the oogonia of the antheridia here referred to *Perimneste*. It is entirely possible that these two genera are the same, but at the present time there is slight evidence to that effect.

PERIMNESTE CORRUGATA Peck, n. sp.
Plate 42, figures 15–24

Small globular bodies about 0.7 mm. in diameter, divided into approximately equal upper and lower hemispheres. Normally four openings penetrate the fairly thick corrugated wall, one at each pole and one at each end of an equatorial axis. One of the openings on the equatorial axis inconspicuous, absent on some specimens, the other well developed and, on many specimens, occurring at the terminus of a strong projection.

Originating around the polar openings are 11 (on some specimens 10, on others 12) furrows that broaden distally, proceeding in a straight line or with a dextral or sinistral curve. Furrows from opposite poles inter-

---

EXPLANATION OF PLATE 43

All figures ×25

All specimens in University of Missouri collections except figure 12.

FIGS. *1–5—Cypridea nitidula* Peck, n. sp. *1–4*, Left valve, dorsal, interior of left valve, and ventral views of paratypes, U.M. 0-975-4. *5*, Right valve of holotype, U.M. 0-975-3. All specimens from the Draney. (p. 301)

6–9—Cypridea longispina Peck, n. sp. *6*, Left valve of holotype, U.M. 0-975-5. *7–9*, Two right valves and dorsal view of paratypes, U.M. 0-974-1. All from the Kootenai. (p. 300)

10–17—Cypridea wyomingensis Jones. *10–13, 16*, Dorsal, right valve, and ventral views of specimens from the Draney, U.M. 0-973-4. *11*, Left valve of spinose specimen from the Kootenai, U.M. 0-972-1. *12*, Right valve of one of the type specimens of *C. tuberculata* var. *gypsumensis* Vanderpool from the De Queen clays of Arkansas, Univ. Oklahoma 505. *14*, Right valve of almost beakless specimen from the Kootenai, U.M. 0-973-5. *15*, Right valve of elongated specimen from the Draney, U.M. 0-973-3. *17*, Left valve of specimen from the Draney, U.M. 0-973-2. (p. 297)

18–28—Cypridea anomala Peck, n. sp. *18, 22, 25*, Right valves of paratypes from the Draney showing variation in ornamentation and shape, U.M. 0-974-5. *19, 21, 23, 24, 26–28*, Paratypes from the Draney, U.M. 0-974-4. *19, 21*, Dorsal and ventral views. *23, 28*, Separate valves showing contact structures. *24*, Right valve of highly nodose specimen. *26, 27*, Left valves showing difference in ornamentation. *20*, Right valve of holotype from the Draney, U.M. 0-973-1. (p. 299)

29–30—Candona sp. indet. Right and left valves from the Draney, U.M. 0-974-2. (p. 297)

31–33—Cypris purbeckensis Forbes? *31*, Ventral view of specimen and, *32, 33*, right valve and dorsal view of specimen, both from the Draney, U.M. 0-974-3. (p. 301)

finger near the equator or meet along a sinuous ridge or against a horizontal furrow; those furrows in the lateral hemisphere containing the produced equatorial opening all curving strongly and terminating at or near this opening. Connecting the equatorial openings along one side is a horizontal furrow, flanked near its terminus at the produced opening by two short horizontal furrows. No horizontal furrow present on opposite side, the furrows from opposite poles meeting along a sinuous ridge or interfingering.

Remarks.—The specimens are divisible into approximately equal quadrants by an equatorial plane bisecting the equatorial openings and a vertical plane bisecting all four openings. For the purpose of orientation the two similar openings are placed as polar in position, the strongly projecting opening away from the observer, and the horizontal furrows on the observer's left. All illustrations are prepared with this orientation.

There is sufficient irregularity on the surface features among the 150 or more specimens studied for this description that it is difficult to phrase a description that will include all possibilities. On the whole, however, the main characters are consistent. These characters are:

1. The division of the specimen into approximately equal halves. These halves are never mirror images, but on some specimens they approach that stage. The furrows from opposed poles meet along a crenulate line, interfinger, or end halfway between the polar opening and the equator and are superseded by other furrows trending in a horizontal direction.

2. On most specimens 11 furrows originate at the polar openings. Some specimens have only 10 furrows and a few have 12.

3. One opening on the equatorial axis is always strongly developed, and the furrows in that lateral hemisphere curve strongly toward it. The opposite opening is always inconspicuous, and on a few specimens I have not been able to find it. When this

---

EXPLANATION OF PLATE 44

All figures ×25

All specimens in University of Missouri collections except figure 32.

FIGS. *1–14*—*Metacypris angularis* Peck, n. sp. *1*, Right valve of unornamented male paratype from the Kootenai, U.M. 0-978-5. *2*, *4*, *7*, *13*, *14*, Paratypes from the Kootenai, U.M. 0-978-4; *2*, ventral view of short inflated female; *4*, dorsal view of female; *5*, left valve of female showing two posterior nodes and nodes on anterior flange; *6*, ventral view of small male; *7*, dorsal view of small nodose male; *13*, left valve of male showing variation in shape; *14*, left valve of small female carapace. *3*, *8*, *9*, *11*, *12*, Paratypes from the Peterson, U.M. 0-977-1; *3*, ventral view of fairly large carapace; *8*, left valve of female with few nodes; *9*, left valve of small carapace with maximum number of nodes; *11*, ventral view of nodose carapace; *12*, dorsal view of female carapace without nodes. *10*, Right valve of holotype from the Peterson, U.M. 0-977-2. (p. 302)

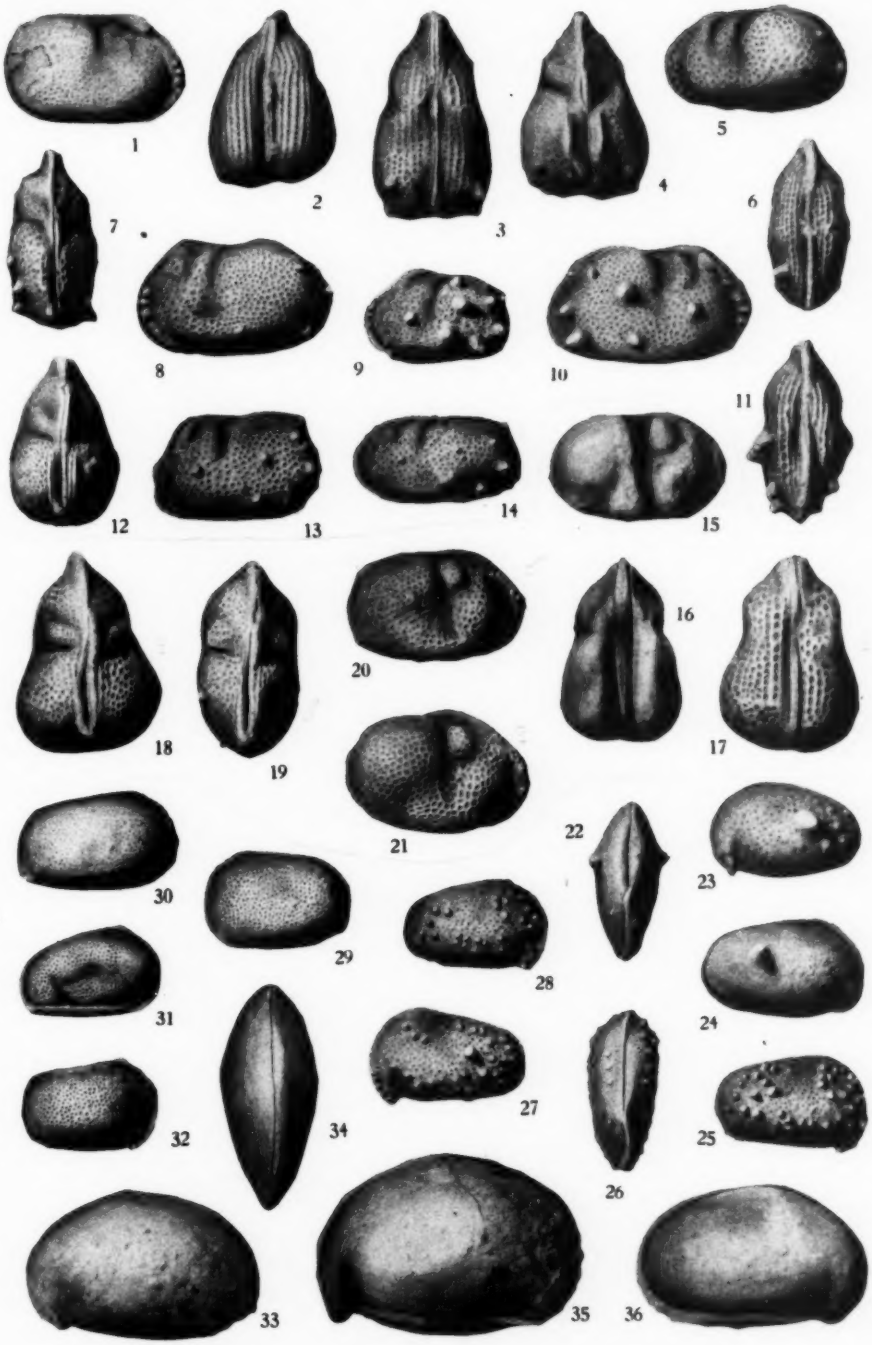
15–21—*Metacypris persulcata* Peck, n. sp. *15–16*, Right valve and ventral view of internal molds from the lower Bear River, U.M. 0-978-3. *17–20*, Paratypes from the lower Bear River, U.M. 0-978-2; *17*, ventral view of female; *18*, dorsal view of female; *19–20*, dorsal and right valve of male. *21*, Right valve of female holotype from the lower Bear River, U.M. 0-978-1. (p. 302)

22–24—*Cypridea brevicornis* Peck n. sp. *23*, Left valve of holotype, U.M. 0-977-5. *22*, *24*, Dorsal view and right valve of paratypes, U.M. 0-976-1. All specimens from the Draney. (p. 299)

25–28—*Cypridea compta* Peck, n. sp. *25*, Right valve of holotype, U.M. 0-976-5. *26*, Dorsal view of paratype from type locality of the Draney, U.M. 0-975-1. *27*, *28*, Left and right valves of paratypes showing variation in ornamentation, U.M. 0-975-2. All from the Draney. (p. 300)

29–32—*Cypridea diminuta* Vanderpool. *29*, Left valve, U.M. 0-976-3. *30*, Right valve of specimen with slight left valve overlap and no evidence of the antero-ventral notch, U.M. 0-976-2. *31*, Right valve of mashed specimen showing anteroventral notch, U.M. 0-976-1. *32*, Right valve of one of the specimens in the type slide of *C. diminuta* Vanderpool from the De Queen formation at Gypsum Bluff, Arkansas, Univ. Oklahoma, 504. (p. 298)

33–36—*Cypridea inornata* Peck, n. sp. *33*, Left valve of holotype, U.M. 0-977-4. *34–36*, Dorsal view, left valve (exfoliated), and right valve of paratypes, U.M. 0-977-3. (p. 301)



Peck, Lower Cretaceous Ostracoda

UNIV. OF MICH.

inconspicuous opening is present and easily recognized the furrows that approach it are usually curved toward it. However, the opening is present on many forms, on which the furrows do not curve.

Harris' (1939) description of *Perimneste horrida* was the first record of antheridia preserved in the fossil state. The antheridia on modern charophyta do not calcify and are never preserved. Harris did not find complete antheridia but simply the exterior wall, where they surrounded and closely adhered to the oogonium. Harris did not have sufficient material to diagnose the antheridia and presumed that it was composed of eight plates (p. 63), as are the modern forms.

If the specimens described above are antheridia, and I know of no other systematic position to which they may be assigned, they differ markedly from the antheridia of modern Charophyta. Groves and Bullock-Webster (1920, p. 46) describe the antheridia as being composed of eight roughly triangular plates with irregularly crenate edges.

The outer surface of the plates is grooved owing to infoldings of the integument forming partial septa. These folds radiate from near the center of the plate to the margin, corresponding with the indentations of the latter. The surface between the grooves is rounded, and the whole plate has the appearance of being exquisitely sculptured in relief.

The specimens here described cannot possibly have been divided into more than two plates.

Occurrence.—Shale in and near the Peterson formation at localities 4 and 10. All the associated charophyte species were found widely distributed in the Peterson and Draney formations, but this genus and species was found only at the two localities. It was found also in the Lower Cretaceous of Texas at a depth of 590–630 feet in shale streaks just above 130 feet of calcareous sandstone identified as the Maxon in the Big Bend Bassett No. 1 well, M. K. and T. E. survey, sec. 15, Blk. D. Terrell County, Texas. These specimens were submitted by Mr. R. H. Schweers of Fort Worth, Texas.

Types.—Univ. Missouri, holotype, 31018-3; and paratypes, 31018-4.

OSTRACODA
Family CYPRIDAE
Genus CANDONA Baird, 1845
CANDONA sp. indet.
Plate 43, figures 29, 30

Carapace large, suboblong, highest posteriorly, anterior margin evenly rounded, posterior obliquely rounded, dorsal margin gently rounded, ventral margin straight or slightly concave. Left valve the larger and overlapping the right everywhere except along the hinge. Surface unornamented.

Length, 1.5 mm.; height, 0.9 mm.; width, 0.6 mm.

Remarks.—Only two specimens of this species were found. They are fairly well preserved but are considered insufficient for specific differentiation. They appear to be closely related to *Candona boloniensis* Jones (1885) from the lower Purbeck and *C. subreniformis* Jones and *C. subovata* Jones (1893) from the Cretaceous near Coalville, Utah.

Occurrence.—Draney formation at locality 5.

Figured specimens.—Univ. Missouri, 0-974-2.

Genus CYPRIDEA Bosquet
CYPRIDEA WYOMINGENSIS Jones
Plate 43, figures 10–17

Cypridea tuberculata var. *wyomingensis* JONES, *1893*, Geol. Mag., decade 3, vol. 10, p. 386, pl. 15, figs. 5a, b; 6a, b.
Cypridea tuberculata var. *gypsumensis* VANDERPOOL, *1928*, Jour. Paleontology, vol. 2, p. 103, pl. 13, figs. 9–12.

Carapace of medium size, subquadrate and angular in lateral outline, highest anteriorly, anterior margin rounded from anterocardinal angle to distal end of small and, on some specimens, inconspicuous beak; posterior margin rounded dorsally, truncate medially, and meeting the ventral surface almost at right angles. The anteroventral notch is small but usually well defined, the ventral margin straight and nearly parallel to the long axis of the carapace, the overlap strong ventrally. Hinge indented, sloping, straight on a majority of specimens, the straightness varied by a dorsal depression just posterior to the anterocardinal angle on a few specimens. Surface of both

valves covered by reticulate network of small pits and numerous more or less irregularly placed nodes. Minimum development of nodes distributed as an irregular double row around the centers of the valves; in maximum development the entire valves are covered, and some specimens possess nodes on the beak.

Length, 1 mm.; height, 0.65 mm.; width, 0.45 mm.

Two specimens that may represent a distinct variety of this species (Plate 43, fig. 15) were collected from different localities. They differ from the species as defined above in failing to attain the height and in having the dorsal and ventral margins almost parallel. They attain the same length as typical representatives of the species and possess the same ornamentation.

Remarks.—The specific description is based on 90 specimens. The outstanding characters of the species are the angular lateral outline, especially the strong anterocardinal angle, and the ornamentation. A few of the Kootenai representatives of this species do not possess a prominent anterocardinal angle, and on a few specimens the beak is not evident.

Jones (1893) considered this a variety of *C. tuberculata* (Sowerby) from the Purbeck and Wealden of England and closely related to *C. tuberculata* var. *adjuncta* Jones (1885) from the Purbeck. Jones states that *C. wyomingensis* has a stronger anterodorsal angle, giving a more pronounced slope to the dorsal border, a stronger notch and hood, weaker tubercles, and less convexity, than *C. tuberculata* var. *adjuncta*. *C. compta*, n. sp. from the Draney and Kootenai formations is smaller than *C. wyomingensis*, has less regular distribution of nodes, and less angularity in outline, especially at the posterior and anterocardinal angle.

C. tuberculata var. *gypsumensis* Vanderpool from the De Queen clays of Arkansas is evidently the same species as *C. wyomingensis* Jones. Vanderpool's specimens are more strongly nodose than most representatives of *C. wyomingensis*, and a few of his specimens do not have the posterior truncation and strong posteroventral angle. These are variations that occur on many specimens from the Draney and Kootenai formations. One of the specimens on Vanderpool's holotype slide is illustrated on pl. 43, fig. 12.

Occurrence.—Widely distributed in Kootenai and Draney formations. Jones (1893) described this species from the Bear River formation near Cokeville, Wyoming. In so far as I have been able to determine the southernmost outcrop of Draney occurs about 25 miles north of Cokeville, but typical fossiliferous Bear River occurs in Smith's Fork northeast of Cokeville. I have examined many samples from the Bear River formation and have at hand a considerable collection of both ostracods and charophyte oogonia. One species of oogonia, a long-ranged form, and one ostracod species are common to both formations, but I have seen no specimen that even remotely resembles *C. wyomingensis* from the Bear River. At the time Dr. White sent the Bear River ostracods to Jones, all of the strata now included in the Gannett formation was considered Bear River. Neither Jones nor White (1895) gave a locality for the ostracods other than "near Cokeville, Wyoming." I believe it is probable that samples were collected from the Draney as well as from the Bear River and submitted to Jones. Some of the species Jones described (1893) are confined to Bear River. In my collecting I have not found *C. wyomingensis* outside of the Draney and Kootenai.

Common in the Draney at localities 5, 6,9, 13, and in the Kootenai limestone at locality 27. Described by Vanderpool (1928) from the De Queen clays of Arkansas as *C. tuberculata* var. *gypsumensis*.

Types.—Location of Jones' types unknown, probably in a British Museum; holotype slide of *C. tuberculata* var. *gypsumensis* Vanderpool at Univ. Oklahoma, number 505—there are five specimens in the slide; figured specimens, Univ. Missouri 0-973-2-5, 0-972-1.

CYPRIDEA DIMINUTA Vanderpool
Plate 44, figures 29–32

Carapace of medium size, thick, rectangular with the angles rounded, highest anteriorly, ventral and dorsal surfaces flattened and nearly parallel, beak and notch inconspicuous. Anterior margin semicircular, posterior margin truncate, meeting ventral

surface at nearly a right angle, posterodorsal margin rounded. Hinge rather long, indented, diverging but slightly from long axis of carapace, anterocardinal angle placed well up toward anterior end of carapace. Overlap strong along ventral margin. Entire surface of both valves covered with a network of fairly large pits.

Length, 0.8 mm.; height, 0.5 mm.; width, 0.3 mm.

Remarks.—This is not a common species in the Draney formation, and the description is based on only eight specimens. *Cypridea punctata* (E. Forbes) from the Purbeck of England and the Wealden of North Germany resembles *C. diminuta* in size and somewhat in lateral outline but possesses a well-developed beak and notch.

Occurrence.—Rare in the Draney formation at localities 6, 18, and 14. Vanderpool (1928) lists the species as common in the De Queen and Glen Rose formations of Texas and Arkansas.

Types.—Holotype, Univ. Oklahoma number 504—there are five specimens in the slide; figured specimens, Univ. Missouri 0-976-2-4.

CYPRIDEA ANOMALA Peck, n. sp.
Plate 43, figures 18–28

Carapace of medium size, subquadrate in lateral outline, strongly angular, highest at anterocardinal angle just anterior to center of longitudinal axis. Anterior and posterior margins broadly rounded or rounded dorsally and truncate medially, meeting the ventral margin almost at right angles. Hinge short, indented, slightly oblique to long axis of carapace. Ventral surface flat, straight, parallel to long axis of carapace. Anterior notch inconspicuous, absent on left valve, entirely absent on some specimens, beak lacking. Sides of valves flat in center, rounding into margin anteriorly and dorsally, meeting ventral surface at right angles and giving quadrate outline to cross section of carapace, sloping abruptly to posterior margin. Surface of both valves pitted; otherwise they may be smooth, nodose anteriorly and posteriorly, or covered with scattered nodes.

Remarks.—This is the most abundant ostracod in the Draney and Kootenai formations, almost every productive sample yielding many individuals. It is easily recognized and distinct from all associated species. The outstanding characteristics are the flat ventral surface, the strong anterocardinal margin, the quadrate outline in cross section, the abrupt lateral slope posteriorly, and the absence of a beak. Some specimens lack nodes entirely, others have a few nodes anteriorly and posteriorly, still others bear nodes over the entire surface. This variation does not seem to be significant as all three types are often present in one sample.

There is some question concerning the generic reference of this species. Jones (1885, p. 33) describes the carapace of the genus *Cypridea* as

> notched at the anteroventral angle, behind a small beaklike process; sometimes having only a slight indentation below and behind a thickening of the anteroventral angle; sometimes this is traceable only by a curvature of the shell inside.

The specimens under consideration do have a thickening of the anteroventral angle and, on most specimens, a slight notch or indentation can be seen behind this thickening on the right (small) valve. No indentation of any sort can be made out on the left (overlapping) valve. The specimens resemble the genus *Cypridea* in all other respects—in hinge characters, overlap, outline, and position and attitude of hinge. It is questionable whether the absence of a beak is of generic importance.

Roth (1933, p. 404) proposed the new generic name *Pseudocypridina* for ostracods lacking an anteroventral notch but otherwise resembling *Cypridea*, and he described a single species, *P. piedmonti*, from the Morrison formation of the Black Hills in South Dakota. Harper and Sutton (1935, p. 625) referred Roth's species to *Cypridea*, stating that Roth had failed to demonstrate the absence of a notch.

Occurrence.—Abundant in all Draney and lower Bear River productive samples and in Kootenai localities 26 and 27.

Types.—Univ. Missouri, holotype 0-973-1; paratypes 0-974-5.

CYPRIDEA BREVICORNIS Peck, n. sp.
Plate 44, figures 22–24

Carapace small, thickened posteriorly, subovate to suboblong in lateral outline,

highest anteriorly, dorsal and ventral margins flattened on some individuals. Anterior and posterior margins unequally rounded; the anterior broadly rounded with a strong notch and beak, the posterior contracted; cardinal angles not prominent. Ventral margin straight or slightly curved, strongly overlapped by left valve, nearly parallel to long axis of carapace. Hinge indented. Surface of both valves covered with very small pits or nearly smooth. A short blunt spine is present just posterior to and above the center of each valve, and back of the spine on a few individuals are irregularly scattered nodes. Part anterior to spine unornamented except for pits.

Length, 0.8 mm.; height, 0.5 mm.; thickness, 0.35 mm.

Remarks.—The description is based on approximately 50 specimens. *C. brevicornis* and *C. compta*, n. sp., may be varieties of the same species. They differ only in ornamentation, but that difference is marked and easily detectable. *C. longispina*, n. sp., from the Kootenai differs in lateral outline and the position of the spine. *C. spinigera* (Sowerby) of the Wealden, England, and also recorded from the Tertiary of the Isle of Wight (Jones and Sherborn, 1889, p. 14) is closely related but is larger and usually has a stronger anterocardinal angle. If these two species occurred in the same strata, the above differences would probably be considered as individual and not of systematic importance, but if the two species could be studied together it is probable that other more constant and important differences would be found.

Occurrence.—Fairly common in the Draney formation at localities 6, 7, 9, 13, 14.

Types.—Univ. Missouri, holotype 0-977-5; paratypes 0-976-1.

CYPRIDEA COMPTA Peck, n. sp.
Plate 44, figures 25–28

Carapace small, thick medially and posteriorly, subovate in lateral outline, highest anteriorly, dorsal and ventral margins flattened. Anterior margin rounded, forming almost a semicircular curve from anterocardinal margin to distal end of small pointed beak; posterior margin rounded. The anteroventral notch small but well defined, the ventral margin straight and nearly parallel to the long axis of the carapace, the overlap strong along the ventral margin. Hinge indented, straight on a majority of specimens, the straightness varied on a few specimens by a dorsal depression just posterior to the anterocardinal angle. Surface of both valves covered by a reticulate network of small pits and a variable number of nodes, the nodes on some specimens almost attaining the proportions of spines. The nodes are concentrated around outer parts of the valves, leaving the center free. Nodes poorly developed to absent on a few specimens.

Length, 0.8 mm.; height, 0.5 mm.; width, 0.35 mm.

Remarks.—This is not a common species, and the above description is based on only 15 specimens. *Cypridea dunkeri* Jones from the Purbeck and Wealden formations of England so closely resembles *C. compta* that they might be considered as varieties of one species. *C. compta* does not narrow anteriorly as much as *C. dunkeri;* it is thicker and more nodose.

Occurrence.—Draney formation at localities 5, 6, 9, and 11; lower Bear River at locality 3a.

Types.—Univ. Missouri, holotype 0-976-5; paratypes 0-975-1.

CYPRIDEA LONGISPINA Peck, n. sp.
Plate 43, figures 6–9

Carapace of medium size, subovate to subtriangular in lateral outline, highest just anterior to the middle; dorsal and ventral margins rounded, overlap strong. Anterior and posterior margins unequally rounded; the anterior broadly rounded with a strong beak and notch, the posterior margin greatly contracted, almost pointed; cardinal angles prominent. Hinge deeply indented, with strong posterior slope, forming an angle of 35° or more with the long axis of the carapace. Ventral margin curved, almost parallel to longitudinal axis. Surface of the valves smooth except for a long blunt spine in the posterior ventral portion.

Length, 0.9 mm.; height, 0.55 mm.; width, 0.45 mm.

Remarks.—This species was collected from a single locality in the Kootenai formation in central Montana. It is common in the one sample. *C. longispina* is the third species

of *Cypridea* to be defined as characteristically possessing a single node or spine. The others are *C. brevicornis*, n. sp., from the Draney limestone and *C. spinigera* (Sowerby) from the Wealden and Tertiary of England. The three species may be closely related, or the addition of the spine may have taken place along three separate lines of development. *C. longispina* differs from the other two species in shape, surface ornamentation, and the position of the spine. The right valve overlap is stronger on *C. longispina* than either of the other species.

Occurrence.—Kootenai formation, locality 23.

Types.—Univ. Missouri, holotype 0-975-5; paratypes 0-974-1.

CYPRIDEA INORNATA Peck, n. sp.
Plate 44, figures 33–36

Carapace large for the genus, slender, semicircular in lateral outline, highest anterior to the center, dorsal and ventral margins rounded. Anterior and posterior margins almost equally rounded, anterocardinal angle obtuse, posterocardinal angle indistinct. Ventral margin slightly curved and parallel to the long axis of the carapace. Hinge slightly indented. Surface of the valves unornamented. Beak and anterior notch fairly well developed.

Length, 1.4 mm.; height, 0.9 mm.; width, 0.5 mm.

Remarks.—This is a smooth characterless species that resembles *Cypridea piedmonti* (Roth) (Harper and Sutton, 1935, p. 625) from the Morrison and, in some respects, resembles members of the genus found in Tertiary strata. *C. inornata* differs from *C. piedmonti* in possessing a well-developed beak and notch and in lacking ornamentation. Tertiary representatives of *Cypridea* have the anterocardinal angle nearer the anterior margin of the carapace. *Cypridea valdensis* (Fitton) of the Purbeck and Wealden of England resembles *C. inornata* in size and somewhat in outline but has a much stronger beak and notch and is shorter posteriorly. Most of the respresentatives of this species are poorly preserved. They are thin-shelled, and on many specimens one shell is partly or wholly exfoliated.

Occurrence.—Kootenai formation at locality 23.

Types.—Univ. Missouri, holotype 0-977-4 paratypes 0-977-3.

CYPRIDEA NITIDULA Peck, n. sp.
Plate 43, figures 1–5

Carapace fairly large for the genus, thickened ventrally, suboblong in lateral outline, ovate in end view with ventral margin flattened, highest anterior to middle. Anterior margin a semicircular curve from anterocardinal margin to end of well-defined beak; posterior margin rounded dorsally, truncate along the posterior margin, and meeting the ventral surface almost at right angles. The anteroventral notch is well defined, the ventral surface flat and nearly parallel to the long axis of the carapace, the overlap strong. Hinge indented, straight, anterocardinal margin angled. Surface of both valves covered with small disconnected circular pits.

Remarks.—*C. nitidula* is abundant and well preserved in the Draney limestone. In lateral outline it somewhat resembles *C. wyomingensis* Jones of the Draney but differs in ornamentation. In size and surface ornamentation *C. nitidula* resembles *Cypridea punctata* (E. Forbes) of the Purbeck of England and the Purbeck-Wealden of North Germany but differs in lateral outline.

Occurrence.—Draney formation at localities 5, 7, 9, and 14; lower Bear River formation at locality 3a.

Types.—Univ. Missouri, holotype 0-975-3; paratypes 0-975-4.

Genus CYPRIS Müller, 1785

CYPRIS PURBECKENSIS Forbes?
Plate 43, figures 31–33

Cypris purbeckensis JONES, *1885*, Geol. Soc. London, Quart. Jour., vol. 41, p. 347, pl. 9, figs. 1–6 (gives complete synonomy up to 1885); ——, *1886*, Geol. Mag., decade 3, vol. 3, p. 147, pl. 4, figs. 5a, 5b, 5c; ——, *1893*, idem, vol. 10, p. 386, pl. 15, figs. 15a, b.

Carapace subreniform, of medium size, rounded dorsally, ventral surface flattened to slightly concave, thickest just below the center. Anterior end more broadly rounded than the posterior. Hinge short, slightly indented. Left valve slightly overlaps right everywhere except at hinge.

Length, 1.1 mm.; height, 0.6 mm.; thickness, 0.6 mm.

Remarks.—*Cypris purbeckensis* Forbes is

a lower Purbeck species of England, and it is improbable that a species confined to the lower division of the Purbeck should appear in North America associated with other species closely resembling those found only in the Wealden. But the species under consideration is undoubtedly the one identified by Jones (1893) as *Cypris purbeckensis* from the Bear River formation, and I am unable to differentiate it from the Purbeck form by means of his descriptions and figures (Jones 1885). Jones' (1886) figures of *C. purbeckensis* from the Morrison of Colorado are quite different from the Bear River and Purbeck illustrations and probably indicate a different species.

Occurrence.—Three specimens were collected at one locality, number 5, from the Draney formation.

Types.—Location of primary types unknown; figured specimens, Univ. Missouri 0-974-3.

Genus METACYPRIS G. S. Brady, 1870
METACYPRIS PERSULCATA Peck, n. sp.
Plate 44, figures 15–21

Carapace of medium size, suboblong to subovate in lateral outline; maximum height at or just posterior to anterocardinal angle, maximum width of male near center of carapace longitudinally and just above ventral surface, of female about midheight and well to the posterior. Posterior margin rounded, grading into the ventral surface and meeting the dorsal surface with an obtuse angle at the posterior end of the hinge; anterocardinal angle evident but not strong, the margin below the angle straight to a point slightly above midheight, then rounded into ventral surface. Ventral surface straight, flat to slightly concave, the concavity most pronounced anteriorly, parallel to long axis of carapace, the line of junction marked by a low ridge formed by slight overlap of right valve. Hinge straight, slanted posteriorly at a low angle, equalling about two-thirds the maximum length of the specimen, depressed posteriorly.

At or just anterior to midlength prominent sulci deeply indent each valve to below the middle, giving the carapace a lobed appearance. Just below the anterocardinal angle originate slight vertical sulci, which swing posteriorly into the large sulci above midheight, isolating a more or less prominent node, which is easily detectable both on carapaces and internal molds. Surface of valve covered with coarse pits, which form a reticulate network on the sides of the valves but are organized into longitudinal rows parallel to junction of the valves along the dorsal and ventral surfaces. Valves otherwise unornamented or possessing a single node at midheight and posterior to prominent sulcus.

Length, 1 mm.; height, 0.61 mm.; width, 0.6 to 0.8 mm.

Remarks.—The coarse pits, rounded outline, deep sulci, isolated anterodorsal node, and single posterior node are distinguishing characters of this species. It is rather difficult to differentiate from the Harper and Sutton (1935, pl. 76, figs. 6, 7) illustrations of the female of *M. pahasapensis* (Roth) from the Morrison, but the median sulcus on their specimens is not as deep and prominent, and the anterior sulcus does not swing back into the posterior. *M. persulcata* bears no resemblance to Jones' species of *Metacypris* (1893) from the Bear River.

Occurrence.—Common as well-preserved specimens and internal molds in the lower Bear River of western Wyoming and eastern Idaho. Locality numbers 2, 3, and 3a.

Types.—Univ. Missouri, holotype 0-987-1; paratypes 0-978-2-3.

METACYPRIS ANGULARIS Peck, n. sp.
Plate 44, figures 1–14

Carapace of medium size, oblong in lateral outline, with dorsal and ventral margins parallel or nearly so. Maximum height at anterocardinal margin or anywhere along the hinge line, maximum breadth slightly below midheight and near the posterior margin. Posterior margin evenly or obliquely rounded, posterocardinal angle not prominent on most specimens; anterocardinal angle strong, the margin below the angle straight or slightly concave to about midheight, then rounded into the ventral margin. Ventral surface straight, flat or slightly concave, the line of junction marked by a low ridge formed by slight overlap of the right valve. Hinge straight, equalling about two-thirds the maximum length of the specimen, depressed posteriorly.

Just anterior to midlength along the hinge

prominent sulci originate, swing anteriorly, then ventrally, and near their terminus at or just below midheight they swing slightly to the posterior. At the anterocardinal angle two less prominent sulci originate and end above midheight. Valves converge rapidly from anterior sulci to form a compressed, keellike node-bearing ridge for the anterior end of the carapace. Posterior end of carapace thick, almost spherical on some of the females.

Surface of valves pitted, the pits forming a reticulate network on the sides of the valves, organized into longitudinal rows parallel to the junction of the valves along the dorsal and ventral surfaces. The longitudinal rows are especially prominent on the ventral surface. Immature individuals, most males, and part of the females nodose. In maximum development three nodes are developed at edge of posterior slope and parallel to the posterior margin, three more just back of prominent posterior sulcus, and one anterior to the ventral end of posterior sulcus. On some individuals, even among the males, no trace of nodes can be made out, but usually the set of three paralleling the posterior margin—the two situated ventrally the most prominent—and the lower one or two of the set of three paralleling and back of the posterior sulcus are present. The rest of the nodes may be entirely absent or represented by small indistinct bumps. The anterior keellike margin always possesses three small closely set nodes at about midheight, and on many specimens there are two small nodes where the anterior margin swings into the ventral surface. Dimensions of mature forms: length, 1 mm.; height, 0.6 mm.

Remarks.—The outstanding characters of the species are the strong anterocardinal angle, the straight anterodorsal slope, the keellike node-bearing anterior termination of the carapace, and the distribution of the nodes. Although Jones' (1893) specimens of *Metacypris* from the Bear River were probably internal molds and, as such, would not possess the above characters, there seems to be no reason for identifying the specimens here described as one of his species.

Occurrence.—*M. angularis* is the most abundant ostracod in the Peterson formation and is common in the Kootenai formation. Peterson limestone locality numbers 4 and 12; Kootenai formation locality numbers 22, 23, 25, and 27.

Types.—Univ. Missouri, holotype 0-977-2; paratypes, 0-978-4-5, 0-977-1.

BIBLIOGRAPHY

ADKINS, W. S., *1932*, Geology of Texas, Stratigraphy: *Univ. Texas, Bull.* 3232.

ARKELL, W. J., *1933*, *The Jurassic system in Great Britain*. Oxford.

BERRY, E. W., *1911*, Correlation of the Potomac formations: *Maryland Geological Survey, Lower Cretaceous*, pp. 152–172.

BRADY, G. S., CROSSKEY, H. W., and ROBERTSON, D., *1874*, The Post-Tertiary Entomostraca: *Palaeont. Soc.*, vol. 28.

FISHER, C. A., *1909*, Geology of the Great Falls coal field, Montana: *U. S. Geol. Survey, Bull.* 356.

GROVES, JAMES, *1925*, Fossil charophyte-fruits from Texas: *Am. Jour. Sci.*, ser. 5, vol. 10, pp. 12–14.

——, *1924*, *Clavator* Reid and Groves: *Jour. Botany*, vol. 62, pp. 116–117.

——, *1933*, Charophyta: *Fossilium Catalogus*, II *Plantae*, pt. 19. W. Junk, Berlin.

HARPER, FRANCES and SUTTON, A. H., *1935*, Ostracodes of the Morrison formation from the Black Hills, South Dakota: *Jour. Paleontology*, vol. 9, pp. 623–628.

HARRIS, THOMAS MAXWELL, *1939*, *British Purbeck Charophyta*. British Mus. (Natural History).

JONES, T. RUPERT, *1862*, A Monograph of the fossil Estheriae: *Palaeont. Soc.*, vol. 14.

——, *1878*, Notes on some foss'l bivalved Entomostraca: *Geol. Mag.*, decade 2, vol. 5, pp 100–110.

——, *1878*, On the Wealden Entomostraca: *Geol. Mag.*, decade 2, vol. 5, pp. 277–278.

JONES, T. RUPERT, *1885*, On the Ostracoda of the Purbeck formation; with notes on the Wealden species: *Geol. Soc. London, Quart. Jour.*, vol. 41, pp. 311–353, pl. 8, 9.

——, *1886*, On some fossil Ostracoda from Colorado: *Geol. Mag.*, decade 3, vol. 3, pp. 145–148, pl. 4.

——, *1893*, On some fossil Ostracoda from southwest Wyoming, and from Utah, U. S. A.: *Geol. Mag.*, decade 3, vol. 10, pp. 385–391, pl. 15.

——, and HINDE, G. J., *1890*, The Cretaceous Entomostraca (Supplement): *Palaeont. Soc.*, vol. 43, pp. 1–70.

——, and SHERBORN, C. D., *1889*, The Tertiary Entomostraca: *Palaeont. Soc.*, vol. 42.

KNOWLTON, F. H., *1893*, Description of a new fossil species of *Chara: Bot. Gazette*, vol. 18, pp. 141–142.

MANSFIELD, G. R. and ROUNDY, P. V., *1916*, Revision of the Beckwith and Bear River formations of southeastern Idaho: *U. S. Geol. Survey, Prof. Paper* 98, pp. 75–84.

MANSFIELD, GEORGE R., *1927*, Geography, geology, and mineral resources of part of southeastern Idaho: *U. S. Geol. Survey, Prof. Paper* 152.

NACE, RAYMOND L., *1936*, Summary of the late

Cretaceous and early Tertiary stratigraphy of Wyoming: *Wyoming Geol. Survey, Bull.* 26.

PECK, RAYMOND E., *1937*, Morrison Charophyta from Wyoming: *Jour. Paleontology*, vol. 11, pp. 83–90, pl. 14.

——, *1938*, A new family of Charophyta from the Lower Cretaceous of Texas: *Jour. Paleontology*, vol. 12, pp. 173–176, pl. 28.

PIA, J., *1927*, in HIRMER, *Handbuch der Palaobotanik*, I, pp. 88–93. Munich and Berlin.

PIA, J., *1935*, in BRÜCKNER, W., and PIA, J., Characeenreste im unteren Teil der Zementsteinschichten (oberer Malm) der Griesstock-Decke am Klausenpass: *Eclogae geol. Helvetiae*, vol. 28, pp. 115–121, pl. 10.

REID, C., and GROVES, JAMES, *1916*, Preliminary report on the Purbeck Characeae: *Royal Soc. London Proc.* B, vol. 89, pp. 252–256.

RICHARDS, R. W. and PARDEE, J. T., *1925*, The Melrose phosphate field, Montana: *U. S. Geol. Survey, Bull.* 780A.

ROTH, ROBERT, *1933*, Some Morrison Ostracoda: *Jour. Paleontology*, vol. 7, pp. 398–405.

VANDERPOOL, H. C., *1928*, Fossils from the Trinity group (Lower Comanchean): *Jour. Paleontology*, vol. 2, pp. 95–107.

WHITE, CHARLES A., *1895*, The Bear River formation and its characteristic fauna: *U. S. Geol. Survey, Bull.* 128.

MANUSCRIPT RECEIVED BY THE EDITOR MAY 31, 1940.

JOURNAL OF PALEONTOLOGY, VOL. 15, NO. 3, PP. 305–306, 3 TEXT FIGS., MAY, 1941

OLIGOPYGUS NANCEI, A NEW ECHINOID FROM VENEZUELA

C. WYTHE COOKE
Geological Survey, Washington, D. C.

ABSTRACT—The occurrence of *Oligopygus* in limestone assigned to the upper part of the Santa Anita formation is an indication that the rock is late Eocene, not Cretaceous or Paleocene, as heretofore supposed.

IN SEPTEMBER 1939 Mr. James W. Nance, a geologist on the staff of the Standard Oil Company of Venezuela, collected the seven echinoids here referred to a new species of *Oligopygus*. The specimens were found in a 6-foot bed of hard dark-gray to brownish-gray limestone near the headwaters of Río Amana in the State of Anzoátegui, Venezuela, about 5 kilometers southwest of Mundo Nuevo, a place near the northwest corner of the State of Monagas.

The limestone containing the fossils is classified by field geologists as near the top of the Santa Anita formation, which had been supposed to be late Cretaceous or Paleocene. However, the matrix attached to one of the echinoids included Foraminifera that T. Wayland Vaughan refers to the genera *Operculinoides*, *Miscellanea?*, *Discocyclina* (*Asterocyclina*), and *Lepidocyclina?* Doctor Vaughan states that these indicate that the age is definitely middle or upper Eocene.

The age suggested by the echinoids is even more specific. The genus *Oligopygus*, so far as known, is restricted to deposits of upper Eocene, Jackson, age. The genotype (*O. wetherbyi* de Loriol) and two other species occur in the Ocala limestone of Florida. One species is represented in an old collection from Geneva County, Alabama, presumably from the Moodys marl. Another is reported by Israelsky (1933) from beds of upper Eocene age in Tamaulipas, Mexico. Two from an undesignated, presumably upper Eocene horizon near Spring Mount, Jamaica, were described by Arnold and Clark (1927, pp. 28–30, pl. 4, figs. 4–11), and four from the upper Eocene (Soldado Rock and Bella Vista) of Trinidad by Jeannet (1928). Lambert (1931, p. 292) attributes two from Cuba to the lower Oligocene, probably because Clark and Twitchell (1915) wrongly assigned to that horizon *O. wetherbyi* and *O. haldemani*, with which Lambert's species were at first identified.

OLIGOPYGUS NANCEI Cooke, n. sp.
Figures 1–3

Test moderately large; outline subpentagonal to subcircular, widest at the anterior ambulacral areas; about half as high as long; upper surface regularly convex; lower surface nearly flat, but flatness accentuated by crushing. Apical system central; four genital pores, widely separated. Petals long, not quite reaching the ambitus, the anterior somewhat longer than the paired petals, straight, open at the distal ends; poriferous zones nearly as wide as the interporiferous zones, slightly curved inward at the tip; pore pairs conjugate; inner pores nearly circular, outer pores elongated. Extrapetalous pores in diagonal pairs becoming linear near the peristome. Peristome central, rather small, deeply sunken in a transversely elliptical pit. Periproct round, flush, about one-third the way from the margin to the peristome. Tubercles fairly large, about the same size on top and bottom; interscrobicular area densely papillated.

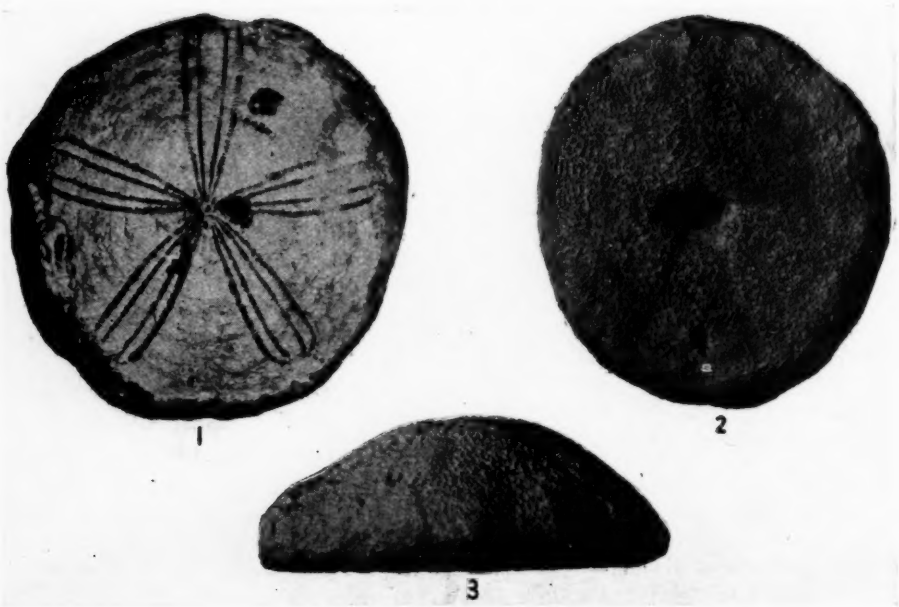
Dimensions of holotype and figured paratype: Length, 51 and 56 mm.; width, 49 and 55 mm.; height (somewhat crushed), 19 and 21 mm.

Occurrence.—Río Amana, Anzoátegui, Venezuela, approximately 5 km. southwest of Mundo Nuevo, Monagas, James W. Nance, collector, in a 6-foot bed of dark-gray to brownish-gray hard limestone. Collection number SOV 30123.

Geologic horizon.—Probably upper Eocene.

Types.—U. S. Nat. Mus. 498964. Seven individuals, all imperfect.

Comparisons.—The peristome and periproct of *Oligopygus nancei* appear to re-



FIGS. *1–3—Oligopygus nancei* Cooke, n. sp. *1, 3*, Top and side of holotype, ×1. *2*, Bottom of a paratype, ×1.

semble those of *O. putnami* Israelski (1933, p. 275, pl. 18, figs. 1–4), but its petals are much longer and straighter than those of the Mexican species, and its base is flatter. Of the three species from the Ocala limestone of Florida figured by Clark and Twitchell (1915, pls. 78, 79), it most closely resembles *O. floridanus* Twitchell, but its peristomial depression is shorter, its periproct is somewhat farther from the peristome, its petals are longer, and its outline is more nearly circular. *O. wetherbyi*, the genotype, has a broader, less well defined depression, and its periproct is farther from the margin. *O. haldemani* (Conrad) has a similar though proportionately larger depression, but its periproct is much nearer the margin, and its petals are shorter.

REFERENCES

ARNOLD, B. W., and CLARK, H. L., *1927*, Jamaican fossil echini: *Harvard College, Mus. Comp. Zoology, Mem.*, vol. 50, no. 1, 84 pp., 22 pls.

CLARK, W. B., and TWITCHELL, M. W., *1915*, The Mesozoic and Cenozoic Echinodermata of the United States: *U. S. Geol. Survey, Mon.* 54, 341 pp., 108 pls.

ISRAELSKY, M. C., *1933*, A new species of echinoid from Tamaulipas, Mexico: *San Diego Soc. Nat. History, Trans.*, pp. 275–276, pl. 18, figs. 1–4.

JEANNET, ALPHONSE, *1928*, Contribution a l'étude des échinides tertiaires de la Trinité et du Venezuela: *Schweizer. paleont. Gesell., Abh.*, Band 48, 49 pp., 6 pls.

LAMBERT, JULES, *1931*, Note sur le groupe des *Oligopygus*, la nouvelle famille des Haimeidae, et sur quelques échinides fossiles de Cuba: *Soc. géol. France, Bull.*, sér. 5, t. 1, pp. 289–304, pl. 17.

PUBLISHED WITH THE CONSENT OF THE STANDARD OIL COMPANY OF VENEZUELA AND BY PERMISSION OF THE DIRECTOR OF THE GEOLOGICAL SURVEY.

JOURNAL OF PALEONTOLOGY, VOL. 15, NO. 3, PP. 307–308, 6 TEXT FIGS, MAY, 1941

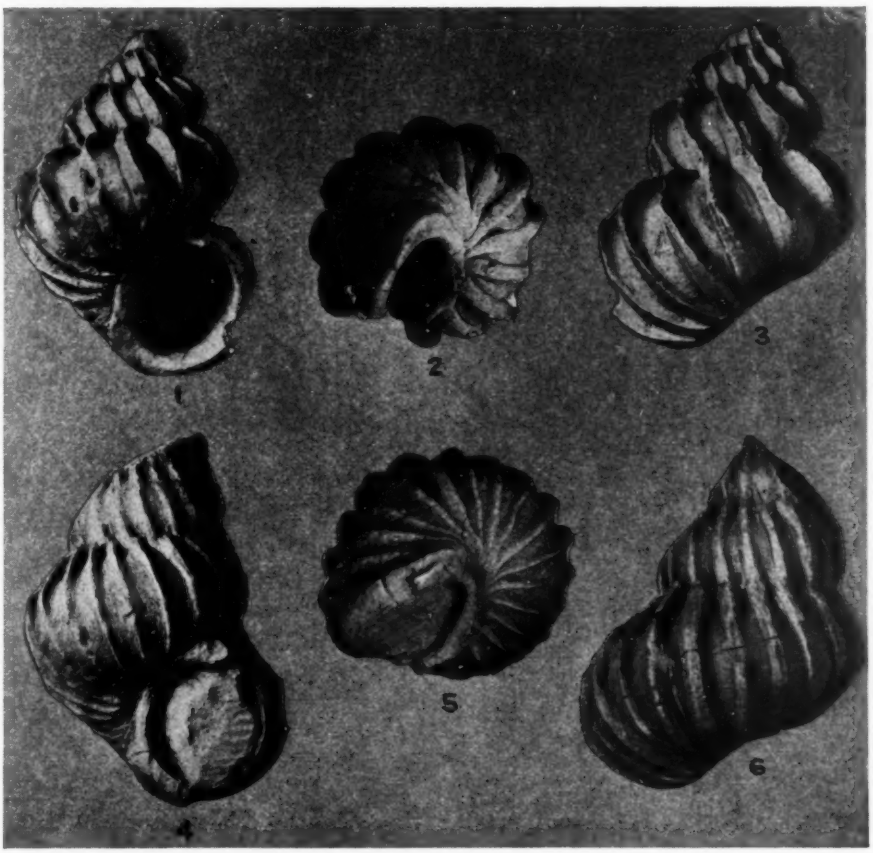
TWO NEW GIANT SCALAS FROM CUBA

PAUL BARTSCH
U. S. National Museum, Washington, D. C.

DR. CARLOS DE LA TORRE has presented the United States National Museum with two fine fossil giant Scalas from Tertiary deposits of Cuba, which I am unable to refer to any of the described species. They are, therefore, now christened.

STHENORYTIS CAROLI Bartsch, n. sp.
Figures 1–3

Shell broadly conic, with inflated, strongly rounded whorls, which bear sigmoid lamellar axial ribs. The summits of the axial ribs fuse with the ribs of the preceding whorl to form oblique, retractively slanting series. Of these ribs 12 are present on each of the remaining four turns. These ribs are sharp at the edge, which bends forward on the posterior third of the whorls between summit and suture, vertical on the middle third and backward directed on the anterior third. The axial ribs pass undiminished over the well-rounded periphery and grow progressively weaker toward the inner lip of the aperture, fusing as they reach this. The intercostal



FIGS. *1–3—Sthenorytis caroli* Bartsch, n. sp., holotype, ×1.
4–6—Sthenorytis torrei Bartsch, n. sp., holotype, ×1.

spaces are considerably wider than the ribs. Suture strongly constricted. Aperture circular; peristome expanded and reflected, narrowest on the parietal wall, where it is adnate to the preceding whorl, somewhat effuse at the junction of the inner and basal lip. The part of the outer lip between the posterior angle and the base is lost, while the basal portion is thickened as a broad rib.

The type, U.S.N.M. 498872, measures: Length, 45.3 mm.; greater diameter, 33.7 mm. It comes from the Oligocene deposits of Nazareno, Havana.

STHENORYTIS TORREI Bartsch, n. sp.
Figures 4–6

Shell large, conic, with well-rounded whorls, whose greatest convexity falls almost on the middle of the turns. The whorls bear strong, slightly retractively slanting, evenly curved, axial ribs, of which 18 are present on the last turn. These ribs are appressed at the summit usually to those of the preceding whorls. Here they are a little narrowed and slightly higher than on the region immediately anterior to the summit and also slightly reflected backward. The major part of the axial ribs is backward curved, giving the left side a slightly flattened aspect and the right side a somewhat excavated appearance. The ribs pass strongly over the well-rounded periphery and the moderately long base, where they become attenuated and fused at the umbilical chink. The area immediately outside of the umbilical chink is thickened to form a moderately broad, depressed-tumid area. Suture rendered irregular by the axial ribs at the summit. Aperture circular; peristome expanded and reflected, broken and lost in the type, from the posterior angle to the middle of the base. Here the last expanded axial ribs show, which in our illustration might be mistaken for the expanded outer peristome. The peristome of the inner lip is narrow, but the portion remaining at the posterior angle and on the basal lip suggests a more expanded outer lip.

The type, U.S.N.M. 352557, has 2.5 whorls remaining and measures: Length, 49.2 mm.; greater diameter, 35.8 mm. It was collected by Francisco Jimeno from the Miocene formation near Matanzas.

MANUSCRIPT RECEIVED BY THE EDITOR JULY 2, 1940.

JOURNAL OF PALEONTOLOGY, VOL. 15, NO. 3, PP. 309–311, 4 TEXT FIGS., MAY, 1941

PROGRANGERELLA, A NEW ANCESTRAL LAND SNAIL FROM THE UPPER CRETACEOUS OF ALBERTA

LORIS S. RUSSELL
Royal Ontario Museum of Paleontology, Toronto, Ontario

ABSTRACT—*Prograngerella sperata*, n. gen., n. sp., is described from the Oldman formation (upper Belly River) of southeastern Alberta. It has a small, low shell, the aperture of which has the thickened lip and the palatal and basal teeth characteristic of the Grangerellidae, but the body whorl of which is normal, and not deflected towards the apex. Grangerellidae have been known previously from the Paleocene of Alberta and the lower Eocene of Wyoming. *Prograngerella* has the expected characters of the Cretaceous ancestor of the family.

THE FAMILY Grangerellidae was established by the writer (1931a) for the reception of a remarkable group of land snails characterized by a peculiar aperture and by a tendency for the body whorl to be deflected obliquely across the spire towards the apex. In *Grangerella mcleodensis*, from the Paleocene of the Alberta foothills, the curiously misplaced aperture reaches only as high as the fourth whorl, whereas in the species from the lower Eocene of northwestern Wyoming, *G. sinclairi* and *G. megastoma*, the deflection extends to the second whorl and to the apex, respectively. Capping of the climax is performed by the aberrant *Protoboysia complicata*, in which the body whorl crosses the apex and starts down the opposite side.

Shells of this family were first described by Professor T. D. A. Cockerell (1912) as *Gastrodonta? evanstonensis* var. *sinclairi*, from the "Wasatch" (Gray Bull) formation of Bighorn basin, Wyoming. Later Cockerell (1914) obtained specimens in which the deflected body whorl was preserved, and he then referred the species to the southern Asiatic genus *Boysia* of Pfeiffer. He also described at this time another species, *Boysia phenacodorum*, and the extraordinary little shell mentioned above, *Protoboysia complicata*. A third paper by this author (1915) established the new genus *Grangerella* and the new species *G. megastoma;* the species previously referred to *Boysia* were included tentatively in the new genus. In these papers, except the first, Cockerell assigns the fossils to the Bulimulidae.

The discovery of abundant and well-preserved material by Princeton University expeditions to the Bighorn basin enabled the writer (1931a) to describe the peculiar characters of the aperture in *Grangerella*. It was shown that *Grangerella megastoma* and "*Boysia*" *sinclairi* were congeneric, and that *Protoboysia complicata* was closely related. "*Boysia*" *phenacodorum* was found to be based on immature specimens of *G. sinclairi*. The new family Grangerellidae was established for the genera *Grangerella* and *Protoboysia*, but the broader relationships of the fossils were left undetermined.

Previously the writer (1929) had described a crushed land snail from the supposed Upper Cretaceous Saunders formation of the Alberta foothills as *Euconulus mcleodensis*. While this description was still in press the writer obtained uncrushed specimens from another locality, revealing the deflected body whorl and peculiar aperture, and permitting redescription (Russell, 1931b) of the species as *Grangerella mcleodensis*. The same field work established the age of the uppermost Saunders beds as Paleocene, rather than Late Cretaceous (Russell, 1932).

It had been pointed out by the writer (1931a) that the Grangerellidae probably had a long history in the late Cretaceous. The first confirmation of this came in 1935, when numerous land snails were collected from the "Pale beds" (Oldman formation) of Milk River valley, Alberta. Most of the specimens represented a new species of *Polygyra*, *P. venerabilis* Russell (1937), but a few fragments indicated the presence of a small grangerellid having the typical aperture but without the deflected body whorl. As these specimens were too poorly preserved to form the basis of a description, the matter was set aside until the locality could be revisited. This was possible in the

summer of 1940, thanks to a grant from the Penrose Fund of the Geological Society of America. This grant permitted a general stratigraphical study of the Canadian plains, and the present contribution is one of several by-products of the project. On this second visit to the land-snail locality the writer and his wife obtained a large number of specimens, including 10 examples of the rare grangerellid, three of which show the characters of the aperture.

DESCRIPTION

Family GRANGERELLIDAE Russell

Pulmonate gastropods of small to medium size. Shells imperforate, rounded-conoid in shape, becoming progressively more elongate during their evolution. Aperture subtrigonal, with outer lip thickened and more or less reflected; palatal and basal foldlike teeth present, with corresponding external sinuses. Body whorl in early evolutionary stages normal but later becoming deflected across spire towards apex, which is reached in some species. Late Cretaceous to early Eocene.

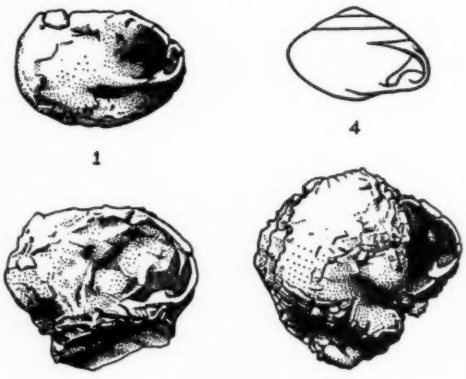
Genus PROGRANGERELLA Russell, n. gen.

A grangerellid of small size, with relatively low spire; 3 to 3½ whorls; body whorl quite undeflected. Outer lip of aperture delicately thickened and slightly reflected; palatal tooth low and oblique, set well within the aperture, and corresponding external sinus located back from lip; basal tooth more prominent, confluent with outer lip. Oldman formation; late Cretaceous.

PROGRANGERELLA SPERATA Russell n. sp.
Figures 1–4

Definition same as for the genus. Maximum diameter of holotype, 4.9 mm.; height, 2.6 mm.

Types.—The holotype is no. 23283, Royal Ontario Museum of Paleontology, invertebrate collection; it is only slightly crushed, but its aperture is damaged. The paratypes, nos. 23284 and 23285, are more distorted but have better-preserved apertures. A third paratype, no. 23286, consists only of the internal filling but shows the uncrushed shape of the spire. The geological horizon is a sandstone member about 150 feet above the base of the Oldman formation ("Pale beds"), for which the name Comrey sandstone has been proposed by the writer (Russell and Landes, 1940). Equivalent horizons would occur about the middle of the Judith River formation, in the upper part of the Two Medicine formation, and near the middle of the Pierre. The age would fall within the Campanian substage of the European standard section. The locality is on the north rim of Milk River valley, southeast of Comrey post office; it is in legal subdivision 2, sec. 3, T. 2, R. 6, west of 4th meridian, Alberta.



FIGS. *1–4—Prograngerella sperata* Russell, n. sp. *1*, Holotype, Royal Ontario Mus. Paleontology no. 23283; oblique basal view to show aperature, which is somewhat broken; ×5. *2*, Paratype, no. 23284; same view as *1;* specimen crushed and attached to fragment of another shell; ×5. *3*, Paratype, no. 23285; same view as *1;* specimen crushed; ×5. *4*, restoration based, except for aperature, on specimen no. 23286; ×5.

Remarks.—The general appearance of the shell in this genus and species is very different from that in the known species of *Grangerella*. In *Prograngerella* the shell is smaller, more compressed, and without the striking deflection of the body whorl. It is the structure of the aperture that reveals the close relationship between the two genera. That of *Prograngerella* is more delicate, with less prominent teeth, but the essential characters in the two genera are the same. These characters are almost unique among gastropods, having their nearest analogues among the neotropical Helicinidae, and it is most probable that they were developed independently in the Grangerellidae. The writer

(1931a), on the basis of an opinion offered by Dr. H. A. Pilsbry, regarded the structure of the aperture in the Grangerellidae as fundamental, and the deflection of the body whorl as a subsidiary specialization, and it is a pleasure to point out how well the present discovery confirms Dr. Pilsbry's suggestion.

In consideration of the structure of the aperture in *Prograngerella* and of the stratigraphical position of the genus, it appears highly probable that we have here the Cretaceous ancestor of the Grangerellidae in the stage where the unique aperture was fully developed but the deflection of the body whorl not yet begun. By Paleocene time the shells had become larger and more elongated, and deflection of the body whorl had carried the aperture part way up the spire (*Grangerella mcleodensis*). In the early Eocene the shells were still larger, and the aperture had reached nearly or quite to the apex (*G. sinclairi, G. megastoma*). At this time we also find a curious side branch of the line represented by *Protoboysia complicata*, in which the shell was small and relatively elongate, and the body whorl, with a constriction at the point of deflection, was carried completely over the apex and part way down the other side of the spire.

It is evident that a stage is still missing from the sequence, that in which the deflection of the body whorl makes its first inconspicuous appearance. There is abundant stratigraphical room for such a stage, and it might be searched for in the Edmonton, St. Mary River, or Lance formations. The St. Mary River beds are the most likely in which to find it, as they have already yielded a number of terrestrial gastropods. When this stage is discovered, it will then be necessary to decide at what arbitrary point in the evolutionary series the genus *Prograngerella* becomes the genus *Grangerella*. This is a common problem with phylogenetic series that embrace several genera. In the present case the definition of *Prograngerella* has been framed to exclude forms in which the deflection of the body whorl has begun, so that our postulated St. Mary River stage would fall within *Grangerella*.

In a paper in preparation the writer intends to discuss the phylogeny of the Grangerellidae, along with that of other groups of nonmarine mollusks, from a more theoretical standpoint.

REFERENCES

COCKERELL, T. D. A., and HENDERSON, JUNIUS, *1912*, Mollusca from the Tertiary strata of the West: *Am. Mus. Nat. History, Bull.*, vol. 31, art. 20, p. 231, pl. 21, figs. 1, 2.

——, *1914*, Land shells from the Tertiary of Wyoming: *idem*, vol. 33, art. 24, pp. 323–325, figs. 1–3.

——, *1915*, Gastropod Mollusca from the Tertiary strata of the West: *idem*, vol. 34, art. 3, pp. 116, 117, fig. 1.

RUSSELL, L. S., *1929*, Upper Cretaceous and lower Tertiary Gastropoda from Alberta: *Roy. Soc. Canada, Trans.*, ser. 3, vol. 23, sec. 4, pp. 88, 89, pl. 1, figs. 19, 20.

——, *1931a*, Early Tertiary Mollusca from Wyoming: *Bull. Am. Paleontology*, no. 64, pp. 25–27, pl. 4, figs. 1–23.

——, *1931b*. Mollusca from the Upper Cretaceous and lower Tertiary of Alberta: *Roy. Soc. Canada, Trans.*, ser. 3, vol. 25, sec. 4, pp. 17, 18, pl. 2, figs. 16–20.

——, *1932*, The Cretaceous-Tertiary transition of Alberta: *Roy. Soc. Canada, Trans.*, ser. 3, vol. 26, sec. 4, pp. 142–147.

——, *1937*, New nonmarine Mollusca from the Upper Cretaceous of Alberta: *Roy. Soc. Canada, Trans.*, ser. 3, vol. 31, sec. 4, pp. 65, 66, pl. 1, figs. 11–13.

RUSSELL, L. S., and LANDES, R. W., *1940*, Geology of the southern Alberta plains: *Canada Geol. Survey, Mem.* 221.

MANUSCRIPT RECEIVED BY THE EDITOR NOVEMBER 12, 1940.

JOURNAL OF PALEONTOLOGY, VOL. 15, NO. 3, PP. 312–317, PL. 45, MAY, 1941

PERMIAN PELECYPODS IN THE LOWER QUARTERMASTER FORMATION, TEXAS

ROBERT ROTH
Humble Oil and Refining Company, Wichita Falls, Texas

NORMAN D. NEWELL AND BENJAMIN H. BURMA
University of Wisconsin, Madison, Wisconsin

ABSTRACT—The age of the Quartermaster formation of Oklahoma and Texas has been the subject of some controversy, being variously given as late Permian or Triassic (?). Fossils have not been reported from these beds until the present discovery of a faunule in the lower part of the Doxey shale at the base of the Quartermaster. Three species are recognized, *Naticopsis transversus* (Beede), *Schizodus oklahomensis* Beede, and *Myalina acutirostris*, n. sp. These forms characterize the recently described Whitehorse fauna and indicate close relationship of the enclosing beds with the Whitehorse formation, even though the Quartermaster fossils occur more than a thousand feet above the lowest fossiliferous horizon of the Whitehorse. If the Whitehorse is Guadalupian (late Permian) in age, then the fossiliferous Quartermaster beds probably are also to be correlated with some part of the Guadalupian or perhaps Ochoa of western Texas.

THE QUARTERMASTER formation, consisting of reddish silty shales and friable sandstones, lies at the top of the Permian red beds in Oklahoma, Kansas, and the Texas Panhandle. In recent years there has been a growing tendency among Mid-Continent geologists to class part or all of the Quartermaster with the Triassic system on the grounds that a regional hiatus separates the Quartermaster from the underlying Cloud Chief. There is considerable disagreement regarding the position and significance of an unconformity in this general part of the column (Green, 1937, p. 1528; Evans, in Green, pp. 1529–1533), but even if an important regional hiatus at the base of the Quartermaster could be demonstrated it would not necessarily imply that these beds should be excluded from the sequence below.

As a result of the studies by one of us along the east side of the Permian Basin, it seems probable that there are several breaks, at least locally, within the Whitehorse-Quartermaster sequence. One of these is at the base of the Dozier lens of the Whitehorse, another at the top of the Cloud Chief, and one at the top of the Doxey shale. In addition, although unrecognized in the field by us, must be noted the unconformity at the base (or in) the Doxey described by Evans (1937, ibid.).

Lithologically the Quartermaster beds resemble some of the Triassic formations of the Rocky Mountain region, but except for the absence of anhydrite beds the Quartermaster also is very similar to the underlying Whitehorse sandstone of probable Guadalupian (late Permian) age.

An age younger than Triassic has not been entertained because the Quartermaster is overlain unconformably by the Dockum group of undoubted Upper Triassic age.

Heretofore fossils have not been known from the Quartermaster beds.[1] Therefore our discovery of a fossiliferous horizon in the lower part of the Quartermaster has important bearing on the age of the enclosing rocks and the location of the Permo-Triassic boundary within the region.

The purpose of this paper is to present the faunal evidence for the age of the fossiliferous beds in the lower Quartermaster.

STRATIGRAPHY

The nomenclature and classification of the Quartermaster and underlying beds summarized in the following table essentially follows that adopted by Green (1937, pp. 1525–1529), except that Green does not recognize the usefulness of the Custer as a stratigraphic unit.

[1] Fossils cited from the Quartermaster by Beede are now known to have come from the lower part of the Whitehorse formation (see Newell, 1940, p. 263).

Upper red beds in Oklahoma and Northern Texas

Major unconformity.
Custer group.
  Quartermaster formation.
    Elk City sandstone.
    Doxey shale.
  Day Creek dolomite.
  Whitehorse formation.
    Cloud Chief gypsum.
    Rush Springs sandstone.
    Marlow member.
Major unconformity.

The fossiliferous horizon occurs near the base of the Doxey shale, therefore in the lowermost part of the Quartermaster, more than a thousand feet above the fossiliferous beds in the lower part of the Whitehorse formation. The Doxey shale is a highly distinctive unit over wide areas and can be readily recognized in the subsurface as well as at the outcrop, so that lithologic correlations generally can readily be made.

One of the more conspicuous characteristics is the presence within the Doxey shale of magenta-colored shales, which attain a thickness of as much as a foot. The texture of these shales is "greasy," like talc or kaolin. They are well laminated and commonly contain very dark greenish-brown biotite. They may have originated as water-laid volcanic ash. Shales of this color do not occur below the Doxey except in the Marlow, where they are associated with the Relay Creek dolomites. The similar shales in the Marlow are but a few inches thick and have long been known to field geologists as "pink" shales. So far as is known the upper Triassic Dockum group, which overlies the Quartermaster, does not contain shales of this color or physical aspect. In the Panhandle of Texas pale magenta-colored shales occur just above the Alibates dolomite wherever the Doxey has not been removed by pre-Dockum erosion. In the Permian Basin area of west Texas pale magenta-colored shales have been recognized as far south as the Big Lake oil field in Reagan County, where they occur just above the Rustler dolomites and anhydrites. A possible correlation is thus suggested between the Rustler and Alibates dolomites.

Since the fossiliferous horizon in the Quartermaster beds is probably near the Day Creek horizon, it is necessary to give due consideration to the possibility that our fossils are from Day Creek equivalents rather than the Doxey shale.

The Day Creek dolomite was first described in Kansas by F. W. Cragin (1896). The "Hackberry" shales of Kansas, which overlie the Day Creek dolomite are classed as Quartermaster by Noel Evans (1931). The Whitehorse formation of Kansas underlies the Day Creek dolomite, but since evaporites are not known to occur at the outcrop in the Whitehorse of Kansas it has been impossible to identify its subdivisions that far north. Much difficulty has been experienced by field geologists in attempting to trace the Day Creek dolomite southward into Oklahoma. Evans and Green are now agreed that this dolomite may be traced as far south as northern Dewey County, Oklahoma before it loses its identity. Massive beds of anhydrite wedge into the section beneath the Day Creek dolomite in northern Oklahoma. These evaporites are included in the Cloud Chief member at the top of the Whitehorse formation. Since Dewey County Oklahoma is 160 miles from our fossil locality in Briscoe County, Texas, and since the Day Creek dolomite does not lithologically resemble the fossiliferous dolomite in Briscoe County, it does not seem advisable at this time to correlate the two horizons, even though they are possibly of nearly the same age. The Alibates and Rustler dolomites and anhydrites possibly also occur in this zone.

On the 13th of April, 1940, a thin fossiliferous dolomite was discovered in the lower Doxey shale in Briscoe County, Texas, approximately at the center of section 63, block E-2, D. & S. F. R. R. Survey.

The following section was measured at the outcrop and shows the general stratigraphic relationships of the pale magenta-colored shales to the Quartermaster. The section was measured just southwest of the southwest corner of section 63 in the above block and survey.

Surface section of Quartermaster beds, Briscoe County, Texas

Feet

Dockum beds.
Unconformity.
Quartermaster formation.
  Elk City sandstone
    1. Sandstone, soft, micaceous, red-

	Feet
dish-orange, with polished grains, locally cross-bedded; local shale conglomerate at base, commonly leached gray, with dark greenish-drab mica, and very large, frosted sand grains.	67.3
Doxey shale	
2. Sandstone, orange, polished grains, very fine except for local grits, interbedded with several beds of pale magenta-colored shale; the whole is very thin bedded, locally rippled.....	48.0
3. Sandstone and terra-cotta shale, orange.....	10.4
4. Sandstone, orange, polished grains, with some pale magenta-colored shale and grits as "shells," locally rippled, with some bench-forming beds.....	68.0
5. Gritty, micaceous sandstone, orange, polished grains, soft...	1.1
6. Sandstone, brilliant orange-red, grains polished or coarse and frosted, soft, some larger grains composed of acid feldspar....	4.0
7. Shale, terra-cotta, micaceous, with some 2- to 4-inch beds of pale greenish-gray shale; the top of this unit contains a zone of leached, polished, sandstone with some large frosted grains; some large sand grains of dark-gray siliceous material, probably chert; the whole thin-bedded and soft.....	46.5
8. Shale, upper part cream colored, unctuous; lower part pale magenta-colored, with some leached zones, contains some biotite; very persistent; the magenta bed is capped by a one-inch bed of light-gray to white dolomite encrusted with silica on the upper surface; a similar dolomite and shade occur at about the same position in the SW cor. sec. 27, T. 10 N., R. 17 W., Okla.....	1.0
9. Shale, terra-cotta; and sandstone with gritty beds, orange, with polished grains, locally cross-laminated and rippled; entire interval cut by dikes and sills of gypsum. The name Bessie silt has been applied to this bed.....	40.0
10. Sandstone, leached, consists of quartz grains, frosted, medium-sized; sporadic at the outcrop, but more or less widespread in the subsurface. A similar bed usually occurs just above the Rustler dolomite in the Permian Basin.....	2.0+
11. Dolomite, oolitic, *fossiliferous*, light-gray to cream-colored where fresh, with a few thin salmon-colored laminae, arenaceous, has thin shale pebble conglomerate at base; just above the dolomite there locally is about 18 inches of leached anhydrite containing biscuits of selenite up to 2 inches in diameter, together with the dolomite very local.....	2.0
12. Shale, pale magenta-colored; grits, light reddish-brown, upper part contains a splendid development of worm tubes. Between the worm tube bed and the dolomite above, there are some thin dolomitic grits, fracture planes coated with malachite.....	2.0
13. Shale, terra-cotta, variable, contains some orange sandstone with polished grains, soft	6.0
Total Doxey shale.....	231.0
Whitehorse formation	
Cloud Chief member	
14. Anhydrite, white, massive, laminated, with pink and gray bands, makes prominent marker (Saddlehorse lentil).....	15.0

Where the Day Creek dolomite is absent the top of the Cloud Chief is drawn at the top of the highest massive anhydrite. Since the contact between the Doxey and the Cloud Chief is based upon a change in lithology one might define the contact as being at the base of the lowest pale magenta shale, or bed 12. The magenta shale could not disappear because of solution. However we prefer to adhere to the definition in general usage. The contact between the Doxey and the Cloud Chief is very easily seen where the surface relief is high, and good clean exposures are formed. Where the relief is comparatively low the separation is not so obvious, because the whole section slumps badly due to the solution of evaporites.

The above section is relatively constant over the area so far as it is exposed. The Dockum overlap locally truncates part or all of the Quartermaster. Beds in the Doxey and underlying Cloud Chief locally are badly slumped due to solution so that the rocks dip in various directions up to 30°.

The fossiliferous dolomite is very local in distribution. Special attention is called to

the beds 10 and 11 in the outcrop section. The magenta shales in beds 8 and 12 are sufficiently uniform and persistent that the intervening section can be recognized and studied over a considerable area. It appears that beds 10 and 11 occur as a local lens in the sedimentary sequence.

FOSSILS

The preservation of the fossils in our collection is extraordinarily good compared with most red-beds faunas. Instead of being preserved as molds, as are the majority of fossils from the El Reno and Whitehorse formations, the shells at hand largely appear to be silicified, so that details of interiors and exteriors are fairly well shown without recourse to artificial casts. The matrix in which the shells occur is a light-gray oolitic and sandy magnesian limestone. When treated with dilute hydrochloric acid parts of the rock effervesce freely, whereas other parts effervesce only feebly. As the fossils are corroded somewhat even by weak acid, presumably they are incompletely silicified.

Although the rock in places virtually is a coquina, the variety of shells is surprisingly small. Representatives of only three species have been recognized, all three being previously known only in the Whitehorse formation (see Newell, et al, 1940). The most abundant form is *Schizodus oklahomensis* Beede. Specimens of this species show considerable variation in form, and in general are small for the species. Comparison of Quartermaster specimens with those from the Whitehorse formation suggests that the former are not fully mature. Many of the Quartermaster specimens essentially are like juveniles from the Whitehorse.

A new species of *Myalina*, represented in our collection by half a dozen specimens, also occurs in the Whitehorse but is exceedingly rare there.

One minute fragment referred to *Naticopsis transversus* (Beede), also a Whitehorse species, is the only representative of the gastropods.

The evidence of the fossils, although indeed scanty, strongly suggests a Permian age for the beds in which they occur, and indicates that these beds are genetically related to the underlying Whitehorse.

DESCRIPTION OF SPECIES

Genus MYALINA De Koninck

MYALINA ACUTIROSTRIS Newell and Burma, n. sp.

Plate 45, figures 11–15

Myalina sp. NEWELL, *1940*, Geol. Soc. Am., Bull., vol. 51, p. 286, pl. 2, fig. 1.

Shell relatively small for a *Myalina*, oblique, subrhombic; surface of both valves relatively smooth; beaks slender, extended anteriorly; with a relatively long hinge about 0.6 to 0.7 as long as the greatest shell length and about equal to the shell height; posterodorsal angle decreasing during growth from very broadly obtuse to about 110° in the most mature individual (holotype); umbonal ridge arcuate in juveniles, tending to become relatively straight at about 45° to the hinge margin (umbonal angle); ventral extremity of the shell tends to be narrowly rounded and placed well back of the center of the shell.

Shell measurements[2]

Specimen	1	2	3	4	5
Length (mm.)	7.5	12.5	20	25	16
Height (mm.)	6.5	9.0	15	19	11
Convexity (mm.)	1.5±	2.5±	2.5±	3±	2.5±
Hinge length (mm.)	5.0	9.0	15.0	20	11.5
Umbonal angle	60°	60°	55°	45°	46°
Posterodorsal angle	128°	115°	120°	110°	—

Remarks.—This species rather closely simulates the group of Pennsylvanian Myalinas generally called *M. perattenuata* and very possibly is derived from the older species. Current studies on late Paleozoic Myalinas by one of the authors indicates that the *perattenuata* group is in fact a genetic series which for stratigraphic purposes profitably can be regarded as a useful genus or subgenus. The present species ap-

[2] All specimens from the Quartermaster locality, left valves, except no. 5, which is a right valve from the Whitehorse formation.

pears to differ from the Pennsylvanian forms in lacking an umbonal septum and in having a nearly, or relatively straight anteroventral margin.

The type specimens are 20846 (holotype) and 20843–20846 at the University of Wisconsin, and 16326 at Yale University.

Genus SCHIZODUS (King) De Verneuil

SCHIZODUS OKLAHOMENSIS Beede

Plate 45, figures 1–9

Schizodus? oklahomensis BEEDE, *1907*, Kansas Univ., Sci. Bull., vol. 4, p. 157, pl. 7, fig. 6.
Schizodus oklahomensis NEWELL, *1940*, Geol. Soc. America, Bull., vol. 51, p. 291, pl. 1, figs. 1–6.

Valves a little longer than high; beaks orthogyre to slightly opisthogyre, and situated approximately one-third of shell length behind anterior margin; front margin extended very slightly, so that the outline is a little too convex to be described accurately as semicircular; ventral margin evenly convex, terminating posteriorly in a rounded angle of 80° to 90° where the rear margin of the shell presents in some specimens a truncated appearance; posterior margin straight to slightly convex, merging with the hinge line in a rounded and broadly obtuse angle; a subdued ridge extends from the beaks to the posteroventral angle of the margin, being slightly concave dorsally in mature specimens, nearly straight in juveniles; posterior area (siphonal area) behind the ridge approximately bisected in mature and well-preserved specimens by an obscure costa, which extends from the beaks to the center of the posterior margin; surface in some unworn specimens ornamented by conspicuous and uniform concentric ridges (fila) which are least prominent on the middle of the shell surface, fila spaced about 10 in 5 mm. near the ventral margin of mature valves; internal characters well shown by the specimens and in full accord with the previously described Whitehorse material.

Shell measurements[3]

Specimen	Length (mm.)	Height (mm.)	Convexity (mm.)
1 (R)	18.0	14.0	4.0
2 (L)	8.5	6.5	2.5±
3 (R)	12.0	9.0	3±
4 (L)	11.0	8.0	3±
5 (R)	8.0	6.0	2±
6 (L)	7.5	5.5	2±
7 (R)	7.0	5.0	—
8 (L)	5.5	6.5	2±
9 (R)	12.0	9±	3±

Remarks.—Two features are noteworthy about the collection of *Schizodus* specimens from the Quartermaster horizon. Most of the specimens obviously are immature or stunted and are very like juveniles from the Whitehorse. Perhaps the prevailing environment of life conditions did not permit these shells to grow to full maturity. The other fact of interest is that the concentric ornamentation believed to be especially distinc-

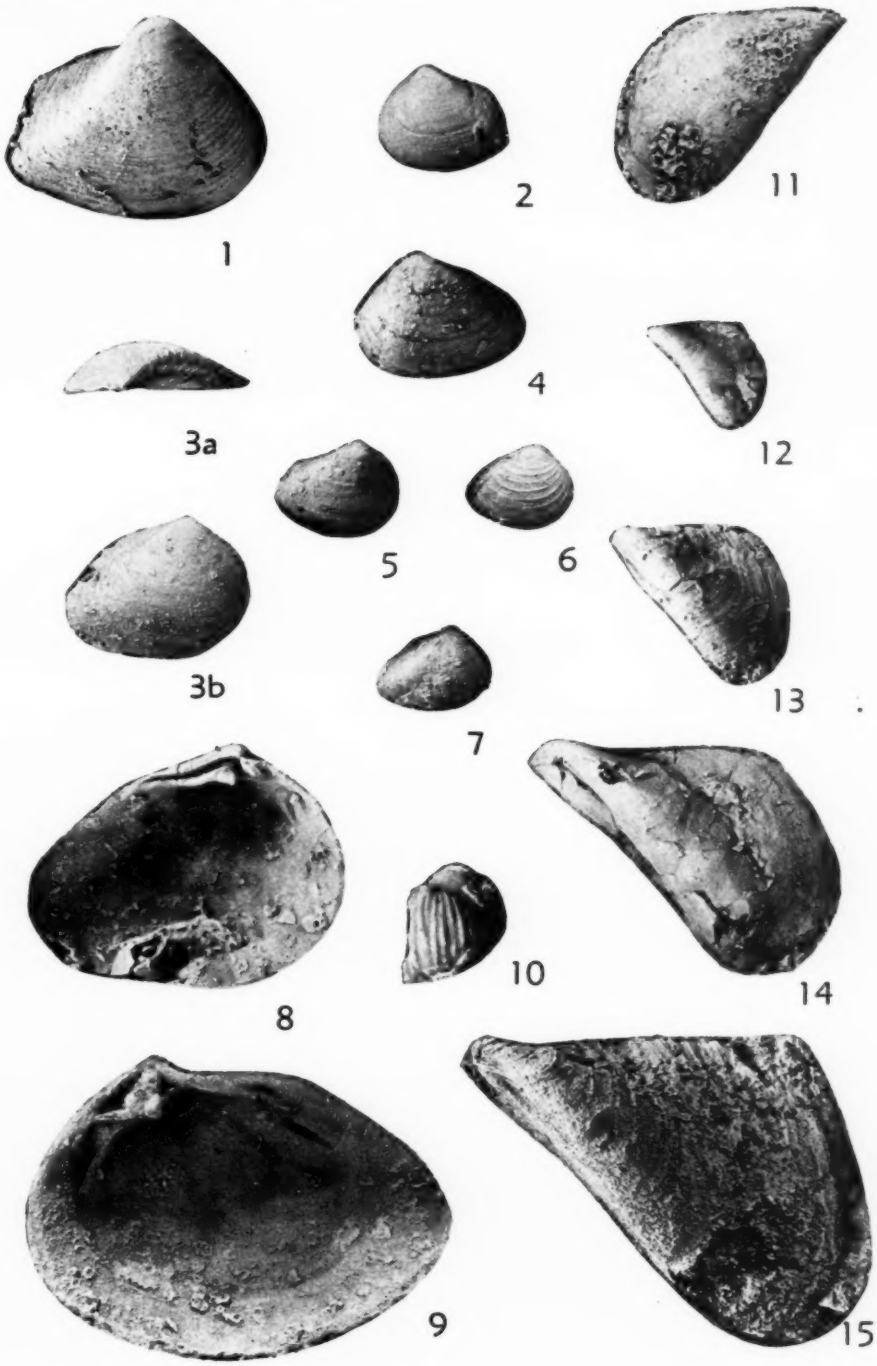
[3] All specimens from the Quartermaster locality except no. 1, which is from the Dozier lens of the Whitehorse.

EXPLANATION OF PLATE 45

FIGS. *1–9*—*Schizodus oklahomensis* Beede. All specimens except fig. *1* from the Quartermaster fossil locality, Briscoe County, Texas. *1*, Rubber cast of a mature right valve, showing well the form and ornamentation thought to be distinctive of the species, ×2, from the Dozier lens of the Whitehorse formation, three miles west of Estelline, Hall County, Texas; hypotype 20807, Univ. Wisconsin. *2*, A small left valve, somewhat less ornate than ordinary for the species, ×2; hypotype 20847, Univ. Wisconsin. *3a–b*, Views of a right valve, somewhat larger than ordinary for the Quartermaster collection, ×2; hypotypes 20848, Univ. Wisconsin. *4*, A typical left valve of medium size, ×2; hypotype 20849, Univ. Wisconsin. *5–7*, Small right valves showing variation in ornamentation, ×2; hypotypes 20850–20852, Univ. Wisconsin. *8, 9*, Well-preserved left and right valves showing dentition of the species, ×5; hypotypes 20853–20854, Univ. Wisconsin. (p. 316)

10—*Naticopsis transversus* (Beede). Small fragmentary hypotype from the Quartermaster locality in Briscoe County, Texas, ×7; 20855, Univ. Wisconsin. (p. 317)

11–15—*Myalina acutirostris*, Newell and Burma, n. sp. All specimens but fig. *11* from the quartermaster in Briscoe County, Texas; all magnifications ×2. *11*, Rubber cast of right valve, from the Whitehorse formation, southwestern Collingsworth County, Texas; paratype 16326, Peabody Mus. Yale Univ. *12–14*, A graded series of left valves showing ontogenetic change in form; topoparatypes 20843–20845, Univ. Wisconsin. *15*, The largest specimen, a left valve, in which growth lines exhibit progressive decrease in the angle between cardinal and posterior margins; the holotype, 20846, Univ. Wisconsin. (p. 315)



Roth, Newell, and Burma, Permian Mollusks

UNIV. OF MICH.

tive of this species is very poorly shown by some individuals. Many specimens are nearly smooth over the more convex part of the shell near the middle of the outer surface but most of the shells exhibit the concentric ridges at the front and rear margins. Perhaps these shells are somewhat worn, but we doubt it.

The specimens are numbered 20807, 20847–20854 at the University of Wisconsin.

Genus NATICOPSIS M'Coy
NATICOPSIS TRANSVERSUS (Beede)
Plate 45, figure 10

Naticella transversa BEEDE, *1907*, Kansas Univ., Sci. Bull., vol. 4, p. 171, pl. 8, figs. 1, 1a.
Naticopsis transversus KNIGHT, *1940*, in NEWELL, Geol. Soc. America, Bull., vol. 51, p. 312, pl. 7, figs. 1–7; pl. 6, figs. 2a–c.

Only one fragment of this form, measuring about 2 mm. in diameter, occurs in our collection. The identification of the species necessarily is somewhat tentative in absence of more complete material. However, the form and ornamentation of our specimen are very like those of the typical material from the Whitehorse formation, and there is no other known Permian species with which it might be confused.

The specimen is No. 20855 at the University of Wisconsin.

REFERENCES

CRAGIN, F. W., *1896*, Permian system in Kansas: *Colorado College Studies*, vol. 6.
EVANS, NOEL, *1931*, Stratigraphy of Permian beds of northwestern Oklahoma: *Am. Assoc. Petroleum Geologists, Bull.*, vol. 15, pp. 405–440.
GREEN, DARSIE A., *1937*, Major divisions of Permian in Oklahoma and southern Kansas: *idem*, vol. 21, pp. 1525–1529. Discussion by Noel Evans, pp. 1529–1533.
NEWELL, NORMAN D., *1940*, Invertebrate fauna of the late Permian Whitehorse sandstone: *Geol. Soc. America, Bull.*, vol. 51, pp. 261–336.

MANUSCRIPT RECEIVED BY THE EDITOR AUGUST 8, 1940.

JOURNAL OF PALEONTOLOGY, VOL. 15, NO. 3, PP. 318–321, 2 TEXT FIGS., MAY, 1941

LEPTOLEPIS NEVADENSIS, A NEW CRETACEOUS FISH

LORE DAVID
California Institute of Technology

ABSTRACT—*Leptolepis nevadensis* n. sp., the first known species of the genus from North America, is described from the "Weber conglomerates" east of Eureka, Nevada. The advanced characters of the structure of the fish suggest Cretaceous age.

DR. S. A. BERTHIAUME while on field work in Nevada during the summer of 1939 discovered a deposit containing fish and plant fossils in the so-called "Weber conglomerates" east of Eureka. These beds have not yielded fossil material heretofore. They were originally mapped as Upper Carboniferous, but this age seemed open to question. Hence the present material, since it can be identified, is of some significance in throwing light on the age of the formation in which it occurs. The fish material has been kindly sent to us by Dr. C. W. Merriam. Fortunately the specimens are for the most part well preserved. They indicate the well-known genus *Leptolepis* Agassiz. The structural characters of the Nevadan species suggest that the deposits in which it occurs are Lower Cretaceous in age.

I am indebted to Dr. Chester Stock of the California Institute of Technology for advice and for a critical reading of the manuscript.

DESCRIPTION OF MATERIAL

The material in the present collection consists of several complete specimens and numerous fragments. The species seems abundant in the region, since the different slabs now at hand indicate the presence of a number of additional specimens in part visible on other bedding planes. The material shows an excellent preservation of details especially in the fins and vertebral column. Most of the bones of the head cannot be distinguished with satisfaction. The proportions of the body of this small species have suffered slightly from distortion; the type shows best the normal proportions in this fish. Some of the syntypes have been lengthened in a post-mortem stage. The material is preserved in a siliceous shale, thinly laminated and of a buff to gray color.

Family LEPTOLEPIDAE

LEPTOLEPIS NEVADENSIS David, n. sp.

Figures 1, 2

Holotype.—A specimen 41 + 9 = 50 mm. in length, no. 10138, California Institute of Technology Coll. Vertebrate Paleontology.

Paratypes.—Ten specimens 33 + 7 = 40 to 48 + 10 = 58 mm. in length and a number of more or less fragmentary specimens. All from Cornell University locality 38C.

Diagnosis.—Body 5.75–6.5 mm. in standard length, head 3.6 mm., orbit a little more than 3 in head; 49 to 50 vertebrae; D. = 14 to 15; A. = 9; V = 8, below posterior part of dorsal fin base; P. = 14; C. = 38. Nine hypurals, five below, four above median line; two epurals.

Description.—Body elongate, depth $5\frac{3}{4}$–($6\frac{1}{2}$) in standard length, caudal peduncle $\frac{2}{3}$ greatest depth. Head $3\frac{3}{5}$ in standard length, elongate $1\frac{1}{3}$ as long as deep. Orbit large (possibly ovoid in shape), slightly more than 3 in head.

The structure of the headbones, in general, does not differ apparently from that described in detail by Rayner (1938). The parasphenoid is always distinct, rising upward toward the front, and situated rather low in most specimens, cutting through the basal part of the orbit. Maxillary with two well-developed supramaxillaries; lower jaw typical for genus, with highly arched dentary. No teeth can be seen. The ceratohyale distinct in several specimens with 10 branchiostegals. Opercular arch as in *Leptolepis*, opercular $1\frac{1}{4}$ as deep as long, with a pronounced diagonal lower border, lower anterior corner sharply pointed.

Vertebrae 34 to 35 + 15 = 49 to 50. Vertebrae pierced by notochord, which is covered by a layer of dark ossified material. The vertebrae constricted in middle, where neural and haemal arches originate, the

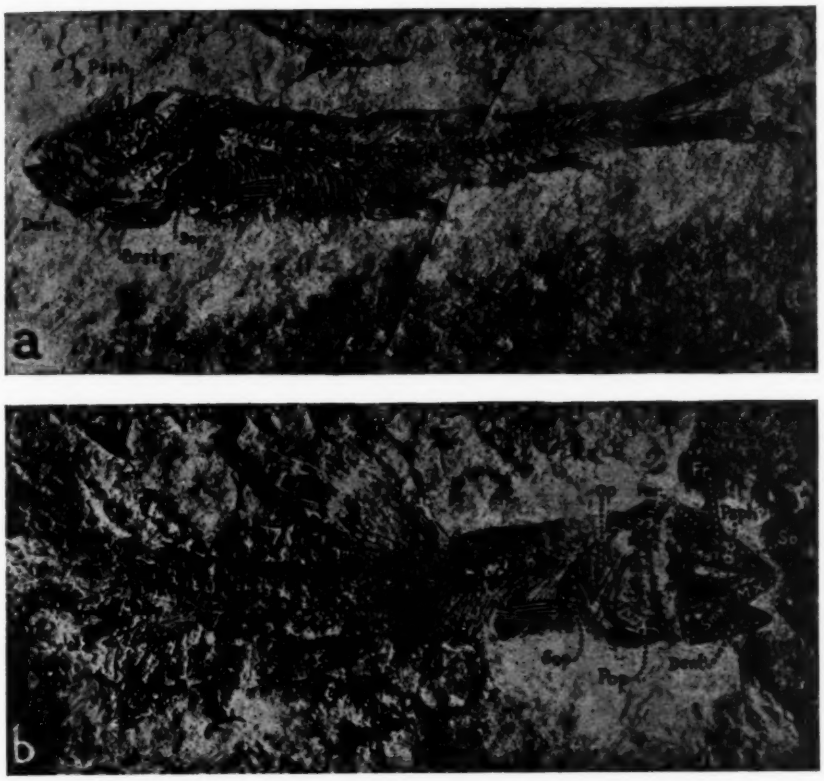


FIG. *1—Leptolepis nevadensis* David, n.sp. *a*, Holotype, no. 10138 Calif. Inst. Tech. Coll. Vert. Paleont.; *b*, no. 10137, ×2. *Fr.*, frontal; *Dent.*, dentary, *Mx.*, maxillary; *Op.*, opercular; *Par.*, parietal; *pop.*, preopercular; *psph.*, parasphenoid; *smx.*, supramaxillary; *so.*, supraorbital; *sop.*, subopercular.

anterior and posterior extremities(zygapophyses?) of the vertebrae projecting into pointed edges. Abdominal neural processes feeble and short, very delicate intermuscular bones lying across; numerous arched and strong ribs extend to ventral border of body.

Structure of tail end of column clearly shown on a small tail fragment, no. 10131 California Inst. Technology Coll. Vertebrate Paleontology (fig. 1). Structure approaches homocerque tail of modern clupeids; only last six vertebrae taking part in structure of tail have prolonged and strong haemal and neural processes. Urostyle slender, pointed; nine hypurals, two more haemal arches prolonged into base of caudal rays; five hypurals below, four above median line; two small epurals, a horizontal rod preceding first caudal fulcra dorsally and ventrally. The haemal processes of the last five vertebrae extend ventrally from the centra for a distance of one-fifth their length and then only are directed posteriorly at a sharp angle, forming enlarged, dagger-shaped hypurals; the end of the ven-

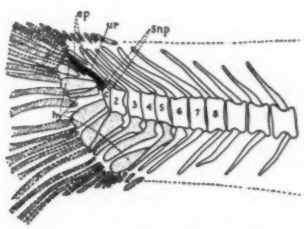


FIG. *2—Leptolepis nevadensis* David, n. sp. Tail end of vertebral column, ×4. *c*, Last vertebral centrum; *ep*, epurals; *hy*, hypurals; *snp*, specialized neural processes; *ur*, urostyle.

tral extension forms a sharp projection pointed forward.

Dorsal rays 14–15: the first two or three short and simple, following rays branched, third or fourth ray longest, two-thirds to three-fourths of head. Dorsal inserted in middle of body or slightly nearer tip of snout. Ventral rays 8: the first strong and simple, fin three-fifths to two-thirds of head, originating below posterior part of dorsal base. Pelvic girdle short, its anterior point not reaching below origin of dorsal. Anal rays 9: longest not longer than ventral, anal fin near to caudal base, distance of anal origin to caudal base 1½ in distance from origin of ventrals to origin of anal. Pectoral with 14 rays, longest ray not longer than ventral, fin situated near ventral border of body. Caudal rays 26+6 pair of fulcra, 38; two middle rays spaced from neighboring rays, prolonged above hypurals. Fin three-fourths of length of head, distinctly furcated, middle rays one-half of longest outer rays.

Body stained dark with an irregular scale-like pattern. No scales are evident.

Affinities of species.—The well-known genus *Leptolepis* Agassiz is widely distributed in Europe and is known from Africa. The genus is first known from the Jurassic (Upper Lias) and continues into the Cretaceous; it has not been reported from deposits younger than Mesocretaceous. Jurassic species of the genus represented by the group of *L. coryphaenoides* Bronn (=L. *bronni* Agassiz), including *L. sprattiformis*, *L. dubius* Agassiz and numerous others, are very different from Cretaceous species. The latter are related to *L. brodiei* Agassiz (see Arambourg 1935, p. 210).

There is no doubt that the *Leptolepis* from near Eureka, Nevada, belongs to the group represented in the Cretaceous. The character that distinguishes most clearly the Cretaceous forms is the transformation of the tail end of the vertebral column. In the Jurassic forms the caudal column is stegoure, while in the Cretaceous forms a progressive transformation takes place to the homocerque type of the living clupeids. The caudal end of the vertebral column in *L. nevadensis* is highly specialized for the genus. It is comparable to the structure seen in *L. congolensis* Arambourg and Schneegans (1935) from the bituminous schists of Coccobeach in French Gabon, and evidently to that of the related species, *L. formosus* Traquair, from the Wealden of Barnissart, Belgium, and of *L. neocomiensis* Bassani from the Cenomanian and Albian, Island of Lesina, Dalmatia. The Purbeckian species *L. brodiei* Agassiz is said to be related to these. Judging from the illustrations, however, the caudal structure of this species seems less specialized. Further evidence of a Cretaceous stage of development of *L. nevadensis* is shown in the following characters: vertebrae of transitional type in degree of perforation by the notochord; the branchiostegals are reduced; the ganoine cover of the scales appears to have been thin; and the dorsal fin is situated over the middle of the body.

As to the immediate affinities of the new species nothing very close seems to be known. The small species with a relatively large orbit may be immature. In its slender body and larger number of vertebrae it differs from any known species of *Leptolepis* (49 or 50). One fragmentary specimen is of much larger size; it may or may not belong to the same species. The structure of the vertebral column, although comparable in degree of transformation of the tail to that in *L. congolensis* Arambourg and Schneegans, shows evident differences in details. The last five haemal processes in *L. congolensis* do not show the distinctive ventral and anterior processes of *L. nevadensis*, the structure and number of hypurals is different, and the first neural process is shortened. Both forms are evidently specialized in different directions. *L. nevadensis*, when compared with the different types of caudal fin-structure shown by the Clupeoidea (Hollister 1936, text figures 3–13), does not show closer relationship to any of these but might be ancestral to them all.

Reports of occurrences of the family Leptolepidae in the Americas are still scanty. A tail, possibly of the leptolepid genus *Thrissops*, has been reported from the Cretaceous of Mexico (Felix, 1890). We can find no reference to the occurrence of *Leptolepis* in the fossil record of North America.

There are two references to occurrences of *Leptolepis* in South America. D'Erasmo (1934) calls attention to a fragment of a head of *Leptolepis* from the Neocomian of Patagonia. The same author (1938) describes an otolith of a member of the Leptolepidae from the Cretaceous of Brazil. He believes that *Haplospondylus clupeoides* Cabrera from the Lower Cretaceous *Leptoceras* strata of Santa Cruz Province, Patagonia, is nearly related to or synonymous with *Leptolepis*.

Because of presence of genera associated with *Leptolepis congolensis* in Coccobeach, which however may have survived *Leptolepis*, Arambourg and Schneegans are able to correlate the Gabon fauna with one of middle or even late Cretaceous age from Bata in Spanish Guinea (Eastman 1912, Weiler 1922). Corresponding Cretaceous faunas have been described from South America—from Bahia, Brazil (Cope 1868, Woodward and Mawson, and Woodward, 1907) and from Riacho Doce in Algaos (Jordan 1910). The age of these South American faunas is not yet assured; they may be Lower or Upper Cretaceous. None of them includes Leptolepid fishes.

Judging from the relationships of *L. nevadensis* to European and African forms, we seem to be justified in regarding the formation near Eureka, whence the specimens came, as of Lower Cretaceous or possibly younger.

REFERENCES

ARAMBOURG, CAMILLE, *1935*, Contribution à l'étude des poissons du Lias supérieur: *Annales de Paléontologie*, vol. 24, p. 1.

ARAMBOURG, C. and SCHNEEGANS, D., *1935*, Poissons fossiles du bassin sedimentaire du Gabon: *idem*. p. 139.

CABRERA, A., *1927*, Sobre un pez fósil del lago San Martin: *Mus. La Plata, Rev.*, vol. 30, p. 317.

D'ERASMO, G., *1934*, Sopra alcuni avanzi fossili della Patagonica: (*R.*) *Accad. Sci. fis. e nat.* (*Soc. R.*) *Napoli*), *Atti*. ser. 2, vol. 20, no. 8.

——, *1938*, Ittioliti cretacei del Brasili: *idem*. (3), 1, no. 3.

FELIX, J., *1890*, Versteinerungen aus der mexicanischen Jura und Kreideformation: *Palaeontographica*, Band 37, p. 140.

HOLLISTER, GLORIA, *1936*, Caudal skeleton of Bermuda shallow-water fishes: *Zoologica*, vol. 21, no. 4.

JORDAN, D. S., *1911*, Description of a collection of fossil fishes from the bituminous shales at Riacho Doce, State Alagaos, Brazil: *Carnegie Mus., Ann.*, vol. 7.

RAYNER, D. H., *1938*, On *Leptolepis bronni* Agassiz: *Annals and Mag. Nat. History*, ser. 10, vol. 19, p. 46.

WEILER, W., *1922*, Die Fischreste aus den bitumösen Schiefern von Ibando bei Bata (Spanisch Guinea): *Palaeont. Zeitschr.*, Band 2.

WOODWARD, A. S., *1916–1919*, The fossil fishes of the English Wealden and Purbeck formations: *Palaeontogr. Soc., Mon.*, pt. 3 (1919), p. 121.

——, *1908*, On some fossil fishes discovered by Prof. Enues de Souza in the Cretaceous formation of Ilheos (State of Bahia) Brazil: *Geol. Soc. London, Quart. Jour.*, vol. 64, p. 358.

MANUSCRIPT RECEIVED BY THE EDITOR SEPTEMBER 30, 1940.

JOURNAL OF PALEONTOLOGY, VOL. 15, NO. 3, PP. 322–323, MAY, 1941

A SECOND SPECIMEN OF CEPHALASPIS PATTENI FROM THE UPPER DEVONIAN OF SCAUMENAC BAY

GEORGE M. ROBERTSON
Fort Hays Kansas State College, Hays, Kans.

THE SPECIES *Cephalaspis patteni* Robertson, 1936, was founded on a single specimen in the Patten collection at Dartmouth College. A restoration based on this specimen had been figured by Patten (1912) and was referred to by Stensiö (1932) as probably a new species. This specimen is a part and counterpart of all but the anterior portion of a shield, plus part of the trunk and of the pectoral appendages. Like the other specimens of *Cephalaspis* from the Bay of Chaleurs region, this specimen is so compressed that scattered traces of dorsal or ventral surface appear at practically the same level as inner aspects of the opposite shield. The ornamentation was very imperfectly preserved, and about all which could be said was that it consisted of tubercles and fine rugae over the general surface, more elongated tubercles on the margins of the cornua, and cordlike massed rugae on the postbranchial bar, the margins of the oralobranchial chamber and orbits, and the ridge along the inner border of the cornua.

In the summer of 1940 Dr. Barbour sent me a specimen from the same area that proves to be a second *Cephalaspis patteni*. Like the holotype it is strongly compressed and consists of a part and counterpart of the shield. The anterior margin is imperfect but sufficiently preserved to indicate that no rostrum was present, the shield thus showing a smoothly rounded margin laterally and anteriorly. The posterior median part of the shield in the holotype is imperfect. The new specimen shows this region with a pronounced median dorsal crista surmounted by an ornamentation of tubercles and rugae. The crista evidently starts slightly behind the orbital region and extends nearly to the posterior margin of the shield.

With the additional information derived from the study of the Harvard specimen the species may be briefly described as follows. *Cephalaspis patteni* is a small species, with a shield approximately 7.5 cm. wide at the widest point, slightly under 3 cm. long. The trunk is longer than the shield, probably 1½ to 2 times as long. The shield is smoothly rounded anteriorly. The cornua are moderately long, directed nearly straight backward, with their inner margins nearly straight, outer margins slightly convex. The pectoral sinuses are broad, with nearly straight anterior borders. The interzonal part of the shield is short and broad. A pronounced median dorsal crista starts posterior to the orbits and runs nearly to the posterior margin of the shield. A long dorsal fin is present on the trunk. The orbits are large and oval, with the nasohypophysial pit between their anterior ends. Ventrally there is a large, nearly circular oralobranchial chamber. The part of the shield posterior to this chamber is solid rather than broken into separate scales. The ornamentation of the dorsal and ventral shields consists of polygonal areas, each polygon having a small cluster of fine tubercles at the center, six groups of fine rugae radiating symmetrically from the center. A postbranchial bar, ridges bordering the oralobranchial chamber, the orbits, and the inner margins of the cornua have a similar pattern except that the rugae are coarser and more prominent parallel to the direction of the ridges. Those on the crista appear to be coarser also. The squamation on the trunk and pectoral appendages is obscure but seems to have had an ornamentation of fine rugae. The dorsal field is not available on either specimen. The lateral fields can be faintly seen on the holotype, but their extent cannot be definitely made out. The horizon is Upper Devonian of Scaumenac Bay, Bay of Chaleurs, Province of Quebec.

The ornamentation is well preserved. On both surfaces of the shield it consists of a polygonal pattern, each polygon having a central tubercle, or more commonly a small cluster of tubercles, from which radiate fine rugae arranged in groups. The pattern of each polygon is hexagonal, six groups of

rugae, with five or six to the group, radiating symmetrically from the center. A similar pattern is maintained on the postbranchial bar, the marginal ridges that border the oralobranchial chamber, the orbits, and the inner margins of the cornua, except that in these places the fine rugae become more coarse and prominent in a direction parallel to the direction of the ridges, giving the appearance described in the previous paper (Robertson, 1936) of "massed striae."

This pattern is of a fairly common type, which occurs also on *C. laticeps*, *C. canadensis*, *C. acadica*, *C. campbelltonensis*, and *C. rosamundae* from the Bay of Chaleurs region. This community of ornamentation pattern suggests a possibility of common genetic groups. A few years ago Mr. Graham-Smith suggested to me that all the Bay of Chaleurs specimens might be different distortions of a single species. I do not believe this to be the case, and in dealing with such a question my experience has brought me to the belief that it is wiser in case of doubt to erect a separate species, even if some later reviser, with more material at his disposal, may have to invalidate the species. That procedure leads to less confusion than does assigning to a single species variant forms which later revisers may have to remove.

I wish to express my thanks to Dr. Barbour and the Museum of Comparative Zoology at Harvard College for the opportunity to study this specimen.

REFERENCES

ROBERTSON, G. M., *1936*, New cephalaspids from Canada: *Am. Journal Sci.*, ser 5, vol. 31, pp. 288–295.

PATTEN, W., *1912*, *The evolution of the vertebrates and their kin*. Blakiston.

STENSIÖ, E. A., *1932*, *Cephalaspids of Great Britain*. British Mus. Nat. History.

JOURNAL OF PALEONTOLOGY, VOL. 15, NO. 3, pp. 324–325, 3 TEXT FIGS., MAY, 1941

A PATHOLOGIC PYGIDIUM FROM THE UPPER CAMBRIAN OF MISSOURI

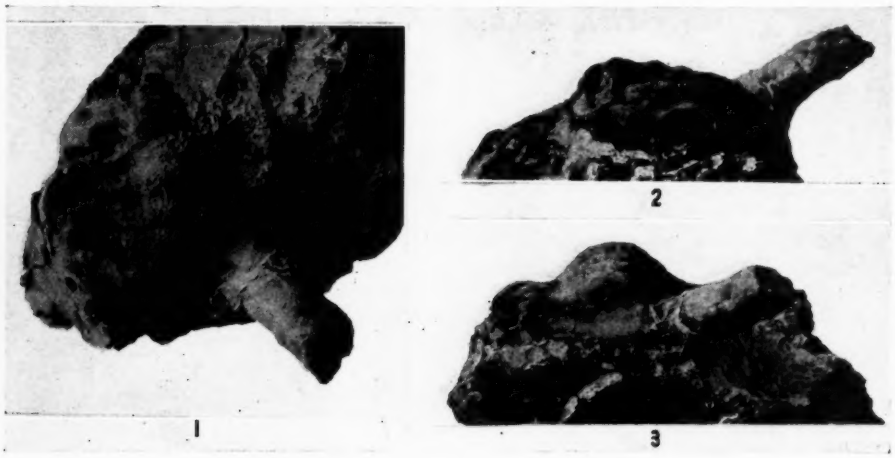
CHRISTINA LOCHMAN
Mount Holyoke College, South Hadley, Mass.

ABSTRACT—An extremely rare specimen, a *Tricrepicephalus* pygidium, shows an excellently preserved scar on the left pleural lobe where the long posterior spine had been broken off cleanly at the base and subsequently healed over with the development of a small amount of callus.

THE DISCOVERY of a fossil specimen showing evidence of an injury received and healed during the animal's life is always of special interest to the paleontologist, as it furnishes a more intimate picture of the life of long-extinct forms.

In the early Upper Cambrian fauna of the Bonneterre dolomite of Missouri, the author obtained a pygidium of *Tricrepicephalus paracomus* Lochman, which possessed, when the specimen was originally deposited, only one posterior spine. The base of the other spine is marked by a prominent scar. The specimen is most unusual not only because it is one of the oldest known instances of trilobite injury, but also because the preservation of the scar is so perfect that the nature of the injury and the healing of the wound may readily be observed.

The two long strong spines of the normal *Tricrepicephalus* pygidium are formed by the hollow tubular outgrowth of the calcareochitinous test of the posterolateral corners of the pleural lobes. They project upward and backward from the pleural lobes and, in all probability, were utilized in defense. Consequently they occupied a most exposed position on the body, and broken or damaged pygidial spines must have been fairly common among the individuals of *Tricrepicephalus*. However, with the exception of the specimen here discussed, only one other clearly demonstrable instance is known to the author, the neoparatype pygidium of *Tricrepicephalus texanus* (Shumard) (Lochman, 1936, pl. 9, fig. 32) in which the tip of the left spine has been bent at right angles to its normal position. Undoubtedly the rarity of such specimens is due to the difficulty attendant upon obtain-



FIGS. 1–3.—*Tricrepicephalus paracomus* Lochman. Dorsal, left side, and rear views of pathologic pygidium showing scar at base of left spine, ×3, Locality 76.20, Ste. Genevieve County, Missouri.

ing well-preserved and complete pygidia, as the spines frequently break off in the rock matrix when the fossils are collected. The type of injury here recorded is the one which has the most likelihood of being preserved and observed.

On the pygidium under consideration the hollow spine was snapped off cleanly at its base, leaving a round open wound in the side of the pleural lobe. The wound apparently healed quickly, as only a small amount of irregular callus formed around the periphery of the opening. In the center of the scar is a small pit produced by the inward contraction of the skin and muscles upon healing (text figs. 1–3). After the wound had been covered by new epidermis, a thin chitinous layer, continuous with the rest of the test, apparently hardened over the surface of the scar.

The development of the scar strongly suggests that among the Trilobites the regeneration of lost parts did not occur at least until the next ecdysis,[1] at which time a small new spine may have appeared on the new carapace. The method of regeneration is apparently the same as that observed in most classes of modern Arthropoda.

REFERENCES

ISBERG, O., *1917*, Ein regeneriertes Trilobitenauge: *Geol. fören Stockholm, Förh.*, Band 39, Heft 5, p. 593.

LOCHMAN, CHRISTINA, *1936*, New trilobite genera from the Bonneterre dolomite (Upper Cambrian) of Missouri: *Jour. Paleontology*, vol. 10, pp. 35–43.

[1] The same conclusion was reached by Isberg (1917), who studied another authentic instance of injury on a trilobite carapace.

SOCIETY RECORDS AND ACTIVITIES

OFFICERS, CORRESPONDENTS, FELLOWS, AND MEMBERS OF THE PALEONTOLOGICAL SOCIETY

OFFICERS FOR 1941

President:

L. W. STEPHENSON, Washington, D.C.

Vice-President:

H. G. SCHENCK, Palo Alto, Calif.

Secretary:

H. E. VOKES, New York, N.Y.

Treasurer:

ROBERT R. SHROCK, Cambridge, Mass.

Editor:

C. WYTHE COOKE, Washington, D.C.

Councilors:

C. O. DUNBAR, New Haven, Conn.
R. W. CHANEY, Berkeley, Calif.
C. W. GILMORE, Washington, D.C.
B. L. Clark, Berkeley, Calif.

MEMBERSHIP

CORRESPONDENTS

ABEL, DR. OTHENIO, University of Göttingen, Göttingen, Germany.
BOULE, MARCELLIN, Musée Nationale d'Histoire Naturelle, 3 Place Valhubert, Paris (5e), France.
BROILI, DR. FERDINAND, Alte Akademie, Munich, Germany.
BROOM, DR. ROBERT, Transvaal Museum, Pretoria, South Africa.
CHAPMAN, FREDERICK, Crohamhurst, 17 Threadneedle St., Balwyn E 8, Melbourne, Victoria.
JONES, PROF. O. T., Sedgwick Museum, Cambridge, England.
KOZLOWSKI, ROMAN, Dept. of Geology, University of Warsaw, Warsaw, Poland.
LANG, DR. W. D., British Museum (Natural History), London S.W. 7, England.
ÖPIK, DR. A., University of Tartu, Tartu, Estonia.
PERNER, DR. J., Karlovy University, Prague VI, Germany.
PIA, DR. JULIUS, Naturhistorisches Museum, Wien I, Burgring 7, Germany.
POULSEN, DR. CHRISTIAN, Mineralogical Museum, Ostervolgade 7, Copenhagen, Denmark.
PILGRIM, DR. G. E., Geological Survey of India, Calcutta, India.
RICHTER, DR. RUDOLF, Viktoria Alle 7, Frankfurt-am-Main, Germany.
RICHTER, MRS. RUDOLF, Senckenberg Museum, Frankfurt-am-Main, Germany.
SCHINDEWOLF, O. H., Invalidenstrasse 44, Berlin 4, Germany.
SILVESTRI, ALFREDO, Via Commenda 26, Milan, Italy.
STENSIÖ, DR. ERICK A., Naturhistoriska Riksmuseum, Stockholm, Sweden.
TROEDSSON, DR. GUSTAV, Helsingborg, Sweden.
VON HUENE, DR. F., Geologisches Institut, der Universität, Tübingen, Germany.
WANNER, DR. JOHAN, Geologische Institut, Bonn, Germany.
WARBURG, DR. ELSA, University of Upsala, Upsala, Sweden.

WATSON, DR. D. M. S., University College, University of London, Gower St., London, W. C. 1, England.
WESTERGAARD, DR. A. H., Geological Survey of Sweden, Stockholm 50, Sweden.
YABE, DR. HISAKATSU, Tohoku Imperial University, Sendai, Japan.

MEMBERS AND FELLOWS

(Fellows are indicated by an *)

ABERDEEN, ESTHER, Wellesley College, Wellesley, Mass.
ALBRITTON, CLAUDE CARROLL, JR., Southern Methodist University, Dallas, Tex.
*ALEXANDER, CHARLES I., Geological Department, Magnolia Petroleum Co., Tyler, Tex.
*ANDERSON, F. M., 58 Hillcrest Road, Berkeley, Calif.
ANDERSON, HOWARD T., Biology Dept., Eastern Oregon Normal School, La Grande, Ore.
*ANDERSON, ROBERT V., c/o Producing Dept., Socony Vacuum Oil Co., Inc., 26 Broadway, New York, N. Y.
*ARNOLD, CHESTER ARTHUR, Dept. of Botany, University of Michigan, Ann Arbor, Mich.
*BALL, OSCAR M., College Station, Tex.
BALL, JOHN R., 701 Emerson St., Evanston, Ill.
BARBAT, WILLIAM FRANKLIN, Standard Oil Company of California, Bin XX, Taft, Calif.
*BARBOUR, ERWIN H., University of Nebraska, Lincoln, Neb.
BARROWS, ALBERT L., 2101 Constitution Ave., Washington, D. C.
*BARTSCH, PAUL, U. S. National Museum, Washington, D. C.
BARWICK, ARTHUR R., Catholic University, Washington, D. C.
BASSETT, CHARLES FERNANDO, University of Kansas, Kansas City, Mo.
*BASSLER, RAY S., U. S. National Museum, Washington, D. C.
BAYS, CARL ANDREWS, Sun Oil Co., 1608 Walnut St., Philadelphia, Pa.
BELL, FRANK J., University of Nebraska State Museum, Lincoln, Neb.
BELL, W. CHARLES, Dept. of Geology, University of Texas, Austin, Tex.
BENTSON, HERDIS, Dept. of Paleontology, Univ. of California, Berkeley, Calif.
BISSELL, HAROLD J., Brigham Young University, Provo, Utah.
BLICK, JOHN C., 3587 Griffith Pk. Blvd., Los Angeles, Calif.
BORN, KENDALL E., Tennessee Division of Geology, Nashville, Tenn.
BOTERO, GILBERTO, 1414 East 59th St., Chicago, Ill.
BOWLES, EDGAR O., Alabama Geol. Survey University, Ala.
BRAMKAMP, RICHARD ALLAN, c/o CASOC, Bahrein Island, Persian Gulf.
*BRANSON, CARL COLTON, Dept. of Geology, Brown University, Providence, R. I.
*BRANSON, E. B., University of Missouri, Columbia, Mo.
BRANSON, EDWIN R., Carter Oil Co., Geological Dept., Tulsa, Okla.
BRANSON, MRS. HERBERTA L. VAN PELT, 103 Butler Ave., Providence, R. I.
BRAUNSTEIN, JULES, Shell Petroleum Corporation, Paleontology Section, Houston, Tex.
*BRIDGE, JOSIAH, Room 337, U. S. National Museum, Washington, D. C.
BRILL, KENNETH GRAY, JR., Univ. of Chattanooga, Chattanooga, Tenn.
*BROWN, BARNUM, American Museum of Natural History, New York, N. Y.
BROWN, BEVERLY, University of Wisconsin, Madison, Wis.
*BROWN, ROLAND WILBUR, U. S. National Museum, Washington, D. C.
BRUFF, STEPHEN, 701 S. Broadway, Santa Ana, Calif.
BUMP, JAMES DYE, South Dakota School of Mines, Rapid City, S. D.
*BUCHER, WALTER H., Dept. of Geology, Columbia University, New York, N. Y.
BUNTON, PAUL B., Spencer Lens Co., 1419 H St., N.W., Washington, D. C.
BURGESS, ANNE EDITH, Rutgers University, New Brunswick, N. J.
*BURLING, LANCASTER D., University of North Carolina, Chapel Hill, N. C.
BUSCH, DANIEL A., University of Pittsburgh, Pittsburgh, Pa.
BUSH, FREDERIC A., 501 Sinclair Bldg., Tulsa, Okla.
*BUTTS, CHARLES, U. S. National Museum, Washington, D. C.

*CAMP, CHARLES L., Museum of Paleontology, University of California, Berkeley, Calif.
*CARMAN, J. E., Ohio State University, Columbus, Ohio.
*CASE, ERMINE C., University of Michigan, Ann Arbor, Mich.
*CASTER, KENNETH E., University of Cincinnati, Cincinnati, Ohio.
*CHANEY, RALPH W., Dept. of Paleontology, University of California, Berkeley, Calif.
CHAPPARS, MICHAEL S., Walker Museum, Univ. of Chicago, Chicago, Ill.
CLARK, ALEXANDER, 1008 West 6th St., Los Angeles, Calif.
*CLARK, BRUCE L., Dept. of Paleontology, University of California, Berkeley, Calif.
CLARK, JOHN, Carnegie Museum, Pittsburgh, Pa.
*CLARK, THOMAS H., Redpath Museum, McGill University, Montreal, P.Q., Canada.
*CLEAVES, ARTHUR BAILEY, Pa. Turnpike Comm., 11 N. 4th St., Harrisburg, Pa.
*CLEMENTS, F. E., 159 Las Encines Ave., Santa Barbara, Calif.
*CLINE, LEWIS MANNING, Dept. of Geology, Iowa Agricultural College, Ames, Iowa.
CLINTON, HENRY G., Black Mammoth Consolidated Mining Company, Manhattan, Nev.
CLOUD, PRESTON E., Dept. of Geology, Missouri School of Mines & Metallurgy, Rolla, Mo.
*COLBERT, EDWIN HARRIS, American Museum of Natural History, New York, N. Y.
*COLE, W. S., Orton Hall, Ohio State University, Columbus, Ohio.
COLLINS, ROBERT E. LEE, Dept. of Geology, University of Tennessee, Knoxville, Tenn.
*CONDRA, G. E., University of Nebraska, Lincoln, Neb.
*COOKE, C. WYTHE, U. S. Geological Survey, Washington, D. C.
COOLEY, MARY ELIZABETH, 703 Forest Ave., Ann Arbor, Mich.
COOPER, CHALMER LEWIS, Illinois Geological Survey, Urbana, Ill.
*COOPER, G. ARTHUR, U. S. National Museum, Washington, D. C.
*CORYELL, HORACE N., Dept. of Geology, Columbia University, New York, N. Y.
*CRAM, IRA H., Pure Oil Co., Box 271, Tulsa, Okla.
*CRICKMAY, COLIN HAYTER, Port Haney, B. C., Canada.
*CRONEIS, CAREY G., Dept. of Geology, University of Chicago, Chicago, Ill.
CULBERTSON, JOHN ARCHER, Continental Oil Co., 612 Oil & Gas Bldg., Houston, Tex.
CULLISON, JAMES, Missouri School of Mines, Rolla, Mo.
*CUMINGS, EDGAR R., Indiana University, Bloomington, Ind.
*CUSHMAN, JOSEPH A., 76 Brook Road, Sharon, Mass.

DAUGHERTY, LYMAN H., San José State College, San José, Calif.
*DECKER, CHARLES E., University of Oklahoma, Norman, Okla.
*DEISS, C. F., Dept. of Geology, University of Montana, Missoula, Mont.
DELO, DAVID, Dept. of Geology, Knox College, Galesburg, Ill.
DENISON, ROBERT HOWLAND, Dartmouth College Museum, Hanover, N. H.
DENSON, NORMAN MACLAREN, Dept. of Geology, Princeton Univ., Princeton, N. J.
*DICKERSON, ROY E., Room 1411, 260 South Broad St., Philadelphia, Pa.
*DORF, ERLING, Dept. of Geology, Princeton University, Princeton, N. J.
DRIVER, HERSCHEL L., 630 West Palm Drive, Glendale, Calif.
DUBOIS, ERNEST PAUL, 963 East 61st Street, Chicago, Ill.
DUCKWORTH, ALBERT STONE, 915 College Hill, Cape Girardeau, Mo.
*DUNBAR, CARL O., Peabody Museum, Yale University, New Haven, Conn.
DUNCAN, DONALD CAVE, U. S. Geological Survey, Washington, D. C.
DUNCAN, HELEN, Montana State University, Missoula, Mont.
DUNN, PAUL HEANEY, Mississippi State College, State College, Miss.
DURHAM, J. WYATT, Dept. of Paleontology, Univ. of Calif., Berkeley, Calif.

EASTON, WM. HEYDEN, State Geological Survey, Urbana, Ill.
*EDWARDS, IRA, Public Museum, Milwaukee, Wis.
EFFINGER, WILLIAM LLOYD, 225 Bush St., San Francisco, Calif.
EHLERS, GEORGE M., University of Michigan, Ann Arbor, Mich.
*ELIAS, M. K., c/o Conservation & Survey Division, Univ. of Nebraska, Lincoln, Neb.

ELLER, E. R., Carnegie Museum, Pittsburgh, Pa.
ELLIS, BROOKS FLEMING, 85 Waller Ave., White Plains, N. Y.
*ELLISOR, ALVA C., Humble Oil & Refining Co., Drawer D, Houston, Tex.
ENDO, RIUJI, The Central National Museum of Manchoukuo, Hsinking, Manchoukuo.
EVANS, CHARLES S., Union Gas Co. of Canada, Chatham, Ont., Canada.

FALKENBACH, CHARLES HENRY, Frick Laboratories, American Museum of Natural History, New York, N. Y.
FANSHAWE, JOHN RICHARDSON, c/o State Well Oil Co., Camp Crook, S. D.
FLOWER, ROUSSEAU H., University of Cincinnati, Cincinnati, Ohio.
*FOHS, F. JULIUS, Fohs Oil Co., Esperson Bldg., Houston, Tex.
FOOTE, FREEMAN, Williams College, Williamstown, Mass.
FOX, STEVEN KNOWLTON, JR., Dept. of Geology, Princeton University, Princeton, N. J.
FREEMAN, LOUISE BARTON, Dept. of Geology, University of Kentucky, Lexington, Ky.
FRICK, CHILDS, American Museum of Natural History, New York, N. Y.
*FRITZ, MADELEINE ALBERTA, 388 Brunswick Ave., Toronto, Ont., Canada.
FRIZZELL, DONALD LESLIE, International Petroleum Co., Ltd., Negritos, Peru.
FRY, WILLIAM WILLCOX, 6420 Cecil Ave., St. Louis, Mo.
FULLÉ, RICHARD M., 550 Park St., Montclair, N. J.
*FURLONG, EUSTACE L., California Institute of Technology, Pasadena, Calif.
FURNISH, WILLIAM M., Dept. of Geology, Oklahoma A. & M. College, Stillwater, Okla.

GALE, HOYT RODNEY, 1775 Hill Drive, Eagle Rock, Los Angeles, Calif.
*GALLOWAY, J. J., Indiana University, Bloomington, Ind.
*GARDNER, JULIA A., U. S. Geological Survey, Washington, D. C.
GARRETT, MRS. EUNICE PETERSON, Swarthmore College, Swarthmore, Pa.
GAZIN, CHARLES LEWIS, U. S. National Museum, Washington, D. C.
GEIS, HAROLD L., Atlantic Refining Co., Edificio La Metropolitana 401, Habana, Cuba.
GILBOE, JOHN DANIEL, Box 999, Bakersfield, Calif.
GILDERSLEEVE, BENJAMIN, Damascus, Va.
*GILMORE, C. W., U. S. National Museum, Washington, D. C.
*GOLDRING, WINIFRED, New York State Museum, Albany, N. Y.
*GORDON, CLARENCE E., Massachusetts Agricultural College, Amherst, Mass.
GORDON, MACKENZIE, JR., Box 59, Route 1, Los Altos, Calif.
*GRANGER, WALTER, American Museum of Natural History, New York, N. Y.
*GRANT, U. S., IV, University of California, Los Angeles, Calif.
GREACEN, KATHERINE FIELDING, Milwaukee-Downer College, Milwaukee, Wis.
*GREENE, F. C., Biltmore Arms Apt., 900 E. 9th St., Kansas City, Mo.
GREGORY, JOSEPH TRACY, Bureau of Economic Geology, Univ. of Texas, Austin, Tex.
*GREGORY, W. K., American Museum of Natural History, New York, N. Y.
GRIES, JOHN PAUL, Dept. of Geology, South Dakota School of Mines, Rapid City, S. D.
GRILEY, H. L., Box 398, Mattoon, Ill.
GROSSMAN, WILLIAM LEWIS, Dept. of Geology, University of Rochester, Rochester, N. Y.
GROVE, BRANDON H., Producing Dept., Socony Vacuum Oil Co., 26 Broadway, New York, N. Y.
*GURLEY, W. F. E. R., 6151 University Ave., Chicago, Ill.

HADLEY, WADE HAMPTON, JR., P. O. Box 1411, Baton Rouge, La.
*HANNA, G DALLAS, Tidewater Associated Oil Co., 79 New Montgomery St., San Francisco, Calif.
*HANNA, M. A., Gulf Production Co. of Texas, Houston, Tex.
HARBISON, ANNE, The Barclay, Rittenhouse Square, Philadelphia, Pa.
HARLTON, BRUCE M., 228 East 27th St., Tulsa, Okla.
*HARRIS, GILBERT D., 126 Kelvin Place, Ithaca, N. Y.

*HARTNAGEL, CHRIS A., New York State Museum, Albany, N. Y.
HAZZARD, JOHN CHARLES, Rm. 1119 Union Oil Bldg., 617 W. 7th St., Los Angeles, Calif.
*HAYNES, WINTHROP P., Rm. 2150, 30 Rockefeller Plaza, New York, N. Y.
HECHT, BERTHA MOLLIE, 240–25 Braddock Ave., Bellerose, Long Island, N. Y.
HEDBERG, HOLLIS DOW, Mene Grande Oil Co., Apartado 35, Ciudad Bolivar, Venezuela.
HEMINGWAY, CAROLINE ELLA, Smith College, Northampton, Mass.
*HENBEST, LLOYD G., U. S. Geological Survey, Washington, D. C.
HENRY, LEONARD W., Richmond Petroleum Co., Apartado 33, Maracaibo, Venezuela.
HERPICH, FRED C., Peabody Museum, Yale University, New Haven, Conn.
HIBBARD, CLAUDE W., Kansas University, Lawrence, Kan.
HIBBARD, RAYMOND R., 219 Bissell Ave., Buffalo, N. Y.
HINCHEY, NORMAN SHREVE, Missouri Geological Survey, Box 138, Rolla, Mo.
HOFFMAN, ARNOLD DANIEL, 1545 E. 60th St., Chicago, Ill.
*HOFFMEISTER, J. E., University of Rochester, Rochester, N. Y.
HOLLINSWORTH, RICHARD VINCEN, 2104 N. Cincinnati St., Tulsa, Okla.
HOLZWASSER, FLORRIE, 3001 Broadway, New York, N. Y.
HOSICK, MRS. E. O., 1115 N. Brand Blvd., Glendale, Calif.
HOSKINS, JOHN HOBART, Dept. of Botany, University of Cincinnati, Cincinnati, Ohio.
HOWARD, EDGAR B., Bryn Mawr, Pa.
HOWARD, HILDEGARD, Los Angeles Museum, Los Angeles, Calif.
*HOWE, H. V., Louisiana State Univ., Baton Rouge, La.
*HOWELL, B. F., Dept. of Geology, Princeton University, Princeton, N. J.
*HUBBARD, BELA, 30 Rockefeller Plaza, New York, N. Y.
HUDDLE, J. W., Dept. of Geology, University of North Carolina, Chapel Hill, N. C.
HUMPHREY, WILLIAM E., Museum of Paleontology, University of Michigan, Ann Arbor, Mich.
HUNTER, FENLEY, P. O. Box 230, Flushing, N. Y.
*HUSSAKOF, LOUIS, American Museum of Natural History, New York, N. Y.
HUSSEY, RUSSELL C., 595 Riverside Drive, Rt. 2, Ann Arbor, Mich.
HUTCHINS, FORBES MEREDITH, 3524 Ontario Ave., Montreal, P.Q., Canada.

IMLAY, RALPH WILLARD, Room 331, U. S. National Museum, Washington, D. C.
*ISRAELSKY, MERLE CATHCART, United Gas Pipe Line Co., P. O. Box 2492, Houston, Texas.

*JACKSON, ROBERT T., Peterborough, N. H.
JENNINGS, OTTO E., Carnegie Museum, Pittsburgh, Pa.
JENNINGS, PHILIP H., Magnolia Petroleum Co., Shreveport, La.
*JEPSEN, GLENN L., Dept. of Geology, Princeton University, Princeton, N. J.
JEWETT, JOHN MARK, State Geological Survey, Lawrence, Kan.
JOHNSON, HELGI, Rutgers University, New Brunswick, N. J.
*JOHNSON, JESSE HARLAN, 1220 Cheyenne St., Golden, Colo.

KAY, J. LEROY, Carnegie Museum, Pittsburgh, Pa.
*KAY, G. MARSHALL, Dept. of Geology, Columbia University, New York, N. Y.
KEEN, A. MYRA, Box 1563, Stanford University, Calif.
*KELLOGG, REMINGTON, U. S. National Museum, Washington, D. C.
*KELLUM, LEWIS B., Museum of Paleontology, University of Michigan, Ann Arbor, Mich.
KELLEY, HOWARD A., 1406 Eutaw Place, Baltimore, Md.
KELLY, WILLIAM A., Michigan State College, East Lansing, Mich.
*KEW, W. S. W., 1215 North Howard St., Glendale, Calif.
KINDLE, CECIL H., The College of the City of New York, 139th St. and Convent Ave., New York, N. Y.
KING, ROBERT E., Midland, Tex.
*KIRK, EDWIN, U. S. Geological Survey, Washington, D. C.

KLEINPELL, ROBERT MISSEN, P. O. Box 62, Bakersfield, Calif.
KLEPSER, HARRY J., Capital University, Columbus, Ohio.
*KNIGHT, JAMES BROOKES, Dept. of Geology, Princeton University, N. J.
*KNIGHT, S. H., University of Wyoming, Laramie, Wyo.
KNOX, ARTHUR STEWART, 65 Bromfield Road, West Somerville, Mass.
KOERNER, HAROLD E., Dept. of Geology, Lafayette College, Easton, Pa.

*LADD, HARRY S., U. S. National Museum, Washington, D. C.
LALICKER, CECIL GORDON, Dept. Geology, University of Oklahoma, Norman, Okla.
LAMBORN, MRS. HELEN MORNINGSTAR, Dept. of Geology, Ohio State University, Columbus, Ohio.
LAMOTTE, ROBERT S., 662 Aileen St., Oakland, Calif.
LANDES, ROBERT W., International Petroleum Co., Casilla 206, Guayaquil, Ecuador, S.A.
*LAUDON, LOWELL R., Dept. of Geology, University of Tulsa, Tulsa, Okla.
LAVERDIÉRE, JOSEPH W., Faculté des Sciences, Boulevard de l'Entente, Quebec, Canada.
LEITH, EDWARD I., Dept. of Geology, Univ. of Manitoba, Winnipeg, Man., Canada.
LEWIS, GEORGE EDWARD, 401 Peabody Museum, New Haven, Conn.
LIMPER, KARL ESSLINGER, Dept. of Geology, Miami University, Oxford, Ohio.
LOCHMAN, CHRISTINA, Dept. of Geology, Mount Holyoke College, South Hadley, Mass.
LOCKWOOD, WILLIAM NOBLE, 311 Downing Street, Buffalo, N. Y.
LOEBLICH, ALFRED RICHARD, JR., 452 College Ave., Norman, Okla.
LOWENSTAM, HEINZ A., Illinois State Museum, Springfield, Ill.
LOZO, FRANK EDGAR, JR., Dept. of Geology, Texas Christian University, Fort Worth, Tex.
*LULL, RICHARD S., Yale University, New Haven, Conn.
LUPHER, RALPH L., Dept. of Geology, State College of Washington, Pullman, Wash.

MACALPIN, ARCHIE J., Museum of Paleontology, University of Michigan, Ann Arbor, Mich.
MACGINITIE, HARRY, Humboldt State College, Arcata, Calif.
MACKAY, DONALD K., 15 Glover Ave., Yonkers, N. Y.
MACNEIL, F. STEARNS, U. S. National Museum, Washington, D. C.
MARSHALL, PAULINE, 601 West 115th St., New York, N. Y.
MARTIN, LOIS T., 772 Santa Ynez Ave., Stanford University, Calif.
MASON, JOHN FREDERICK, Dept. of Geology, Princeton University, Princeton, N. J.
*MATHER, K. F., Harvard Geological Museum, Cambridge, Mass.
MAXSON, JOHN HAVILAND, Dept. of Geology, California Institute of Technology, Pasadena, Calif.
MCEWAN, EULA D., University of Nebraska, Lincoln, Neb.
*MCFARLAN, ARTHUR C., Fairway Drive, Lexington, Ky.
MCGLAMERY, WINIFRED, State Geological Survey, University, Ala.
MCGREGOR, J. H., Columbia University, New York, N. Y.
*MCKEE, EDWIN DINWIDDIE, Grand Canyon, Ariz.
MCNAIR, ANDREW HAMILTON, Box 823, Hanover, N. H.
MEFFERD, RALPH LEROY, Ainsworth, Neb.
MELLEN, F. F., Iuka, Miss.
MENCHER, ELY, Instituto de Geología, Avenida San Martin 369, Caracas, Venezuela, S. A.
*MERRIAM, CHARLES W., Laboratory of Paleontology, Cornell University, Ithaca, N. Y.
*MERRIAM, JOHN C., Carnegie Institution, Washington, D. C.
MESLER, RECTOR D., U. S. Geological Survey, Washington, D. C.
*MEYERHOFF, HOWARD A., Dept. of Geology, Smith College, Northampton, Mass.
*MILLER, ARTHUR K., Dept. of Geology, State University of Iowa, Iowa City, Iowa.
MILLER, B. MAXWELL, Texas Co., P. O. Box 2420, Tulsa, Okla.
MILLER, RALPH LEROY, Dept. of Geology, Columbia Univ., New York, N. Y.

MOORE, CARL A., Standard Oil Co. of New Jersey, Room 2130, R.C.A. Bldg., New York, N. Y.
MOORE, PRENTISS D., Box 753, Midland, Tex.
*MOORE, RAYMOND C., University of Kansas, Lawrence, Kan.
MORAN, ROBERT B., 215 West 7th Street, Los Angeles, Calif.
MOREMAN, W. L., Magnolia Petroleum Co., Box 971, Oklahoma City, Okla.
*MORSE, WILLIAM C., University of Mississippi, University, Miss.
*MULLER, SIEMON W., Dept. of Geology, Stanford University, Calif.

NADEAU, MRS. E. H., 2572 W. Point Drive, Maplewood (St. Louis Co.), Mo.
*NEEDHAM, CLAUDE E., Dept. of Geology, New Mexico School of Mines, Socorro, N. M.
NEELY, JOSEPH, Box 1828, Oklahoma City, Okla.
NELSON, ELMER R., Public Museum, Milwaukee, Wis.
*NEWELL, NORMAN D., Dept. of Geology, Univ. of Wisconsin, Madison, Wis.
NOMLAND, JORGAN O., 160 Bell Ave., Piedmont, Calif.
NORTHROP, STUART A., University of New Mexico, Albuquerque, N. M.

*OKULITCH, VLADIMIR J., Royal Ontario Museum of Paleontology, Toronto 5, Ont., Canada.
OLSON, EVERETT CLAIRE, Walker Museum, University of Chicago, Chicago, Ill.
*OLSSON, AXEL A., 48 Woodside Ave., Gloversville, N. Y.
OWEN, JOHN BRITTS, Clinton, Mo.

*PACK, R. W., P. O. Box 2831, Beaumont, Tex.
*PACKARD, EARL L., 13 Edgewood Way, Corvallis, Ore.
PALMER, MRS. D. K., Neptuno 1860, Havana, Cuba.
*PALMER, MRS. KATHERINE VAN WINKLE, 206 Oakhill Road, Ithaca, N. Y.
PEABODY, FRANK E., Dept. of Paleontology, Univ. of California, Berkeley, Calif.
*PECK, RAYMOND E., Swallow Hall, University of Missouri, Columbia, Mo.
PECK, W. H., Box 212, Ekalaka, Mont.
*PETRUNKEVITCH, ALEXANDER, Osborn Zool. Laboratory, Yale Station, New Haven, Conn.
PHLEGER, FRED B., JR., Dept. of Geology, Amherst College, Amherst, Mass.
PLOGER, LOUIS WILLIAM, 254 Roosevelt Ave., Syracuse, N. Y.
*PLUMMER, FREDERICK B., Bureau of Economic Geology, University of Texas, Austin, Tex.
*PLUMMER, MRS. HELEN, 3109 Walling Drive, Austin, Tex.
*POHL, ERWIN R., Horse Cave, Ky.
POPENOE, WILLIS PARKISON, Dept. of Geology, California Inst. Technology, Pasadena, Calif.
POTTER, FRANKLIN CARL, Ohio University, Athens, Ohio.
PROUTY, CHILTON EATON, University of North Carolina, Chapel Hill, N. C.

RAASCH, GILBERT O., Milwaukee Public Museum, Milwaukee, Wis.
RADABAUGH, ROBERT E., Dept. of Geology, Miami University, Oxford, Ohio.
RAINWATER, MRS. E. H., 3021 Cason Street, Houston, Tex.
*RATHBUN, MARY JANE, U. S. National Museum, Washington, D. C.
*RAYMOND, PERCY E., Museum of Comparative Zoology, Cambridge, Mass.
READ, WILLIAM FRANKLIN, West Texas State College, Canyon, Texas.
*REEDS, CHESTER A., P. O. Box 142, Ghent, N. Y.
*REESIDE, JOHN B., JR., U. S. National Museum, Washington, D. C.
*RESSER, CHARLES E., U. S. National Museum, Washington, D. C.
REINHART, PHILIP WINGATE, Shell Oil Co., 1008 W. 6th St., Los Angeles, Calif.
RICHARDS, EDWARD F., Dept. of Geology, University of Alabama, University, Ala.
RICHARDS, HORACE GARDINER, 509 Woodland Terrace, Philadelphia, Pa.
RICHEY, KING A., Dept. of Geology, Calif. Institute of Technology, Pasadena, Calif.
RIGNEY, HAROLD WILLIAM, Catholic Mission, P. O. Box 247, Accra, B. W. Africa.

*ROBERTS, JOSEPH K., University of Virginia, Charlottesville, Va.
ROBINSON, WILBUR I., Texas Technological College, Lubbock, Tex.
*ROMER, A. S., Museum of Comparative Zoology, Cambridge, Mass.
ROOT, TOWNER B., P. O. Box 218, Hamilton, N. Y.
ROSSELLO, PIERINA, Dept. of Paleontology, Univ. of California, Berkeley, Calif.
ROTHWELL, THOMAS, Richfield Paleontology Lab., P. O. Box 470, Long Beach, Calif.
*RUEDEMANN, RUDOLF, New York State Museum, Albany, N. Y.
*RUSSELL, LORIS S., Royal Ontario Museum of Paleontology, Toronto 5, Ont., Canada.
RUTH, JOHN W., Geology Dept., Standard Oil Co., Standard Oil Bldg., Los Angeles, Calif.
RYNIKER, CHARLES, Gypsy Oil Company, P. O. Box 661, Tulsa, Okla.

SALMON, ELEANOR SEELY, 600 West 113th St., New York, N. Y.
SANBORN, ETHEL I., Oregon State College, Corvallis, Ore.
SANDER, NESTOR, Geology Dept., Standard Oil Co., Standard Oil Bldg., Los Angeles, Calif.
*SANDIDGE, JOHN R., Magnolia Petroleum Co., 1704 Alamo Natl. Bldg., San Antonio, Tex.
SANFORD, JOHN THERON, Magnolia Petroleum Co., Box 1828, Oklahoma City, Okla.
*SCHENCK, HUBERT G., Dept. of Geology, Stanford University, Calif.
SCHENK, EDWARD THEODORE, National Park Service, Box 755, Boulder City, Nev.
SCHEVILL, WILLIAM E., Museum of Comparative Zoology, Cambridge, Mass.
*SCHLAIKJER, ERICH M., Brooklyn College, Bedford Avenue & Avenue H, Brooklyn, N.Y.
SCHOONOVER, LOIS MARGARET, 624 Third St., Marietta, Ohio.
SCHOPF, JAMES MORTON, Illinois State Geological Survey, Urbana, Ill.
*SCHUCHERT, CHARLES, Peabody Museum, Yale University, New Haven, Conn.
*SCHULTZ, BERTRAND, Morrill Hall, University of Nebraska, Lincoln, Neb.
SCOBEY, ELLIS H., Dept. of Geology, University of Iowa, Iowa City, Iowa.
*SCOTT, GAYLE, Dept. of Geology, Texas Christian University, Fort Worth, Tex.
*SCOTT, GLENN E., 103 Mound Ave., Milford, Ohio.
*SCOTT, HAROLD WILLIAM, Dept. of Geology, University of Illinois, Urbana, Ill.
*SCOTT, WILLIAM BERRYMAN, Princeton, N. J.
SECRIST, MARK H., Dept. of Geology, Johns Hopkins University, Baltimore, Md.
*SELLARDS, ELIAS H., University of Texas, Austin, Tex.
SHIDELER, WILLIAM H., Miami University, Oxford, Ohio.
*SHIMER, HERVEY W., Massachusetts Institute of Technology, Cambridge, Mass.
*SHROCK, ROBERT R., Dept. of Geology, Massachusetts Inst. of Technology, Cambridge, Mass.
*SIMPSON, GEORGE G., American Museum of Natural History, New York, N. Y.
*SKINNER, MORRIS F., Frick Laboratories, American Museum of Natural History, New York, N. Y.
SLOSS, LAURENCE L., Montana School of Mines, Butte, Mont.
*SMITH, BURNETT, West Lake St., Skaneateles, N. Y.
*SMITH, EDWARD S. C., Dept. of Geology, Union College, Schenectady, N. Y.
SMITH, ERNEST RICE, 309 Greenwood Ave., Greencastle, Ind.
SMITH, HOMER JAMES, Dept. of Geology, University of Tulsa, Tulsa, Okla.
*SMITH, STANLEY, The University, Bristol, England.
*SNIDER, LUTHER C., 110 Crescent Ave., Leonia, N. J.
SOUTHWORTH, CHARLES H., Thedford, Ontario, Canada.
*SPIEKER, EDMUND M., Ohio State University, Columbus, Ohio.
SPIVEY, ROBERT CHARLES, University of Iowa, Iowa City, Iowa.
STAINBROOK, MERRILL A., Texas Technological College, Lubbock, Tex.
*STANTON, T. W., U. S. National Museum, Washington, D. C.
*STAUFFER, CLINTON R., University of Minnesota, Minneapolis, Minn.
*STEPHENSON, L. W., U. S. Geological Survey, Washington, D. C.
STEPHENSON, MORTON B., Dept. of Geology, Louisiana State University, Baton Rouge, La.
STERNBERG, CHARLES M., Geological Survey of Canada, Ottawa, Ont., Canada.

STERNBERG, CHARLES WILLIAM, 6407 University Ave., Chicago, Ill.
STERNBERG, GEORGE F., Kansas State Teachers College, Hays, Kan.
STERNBERG, RAYMOND M., Royal Ontario Museum of Paleontology, Toronto 5, Ont., Canada.
*STETSON, HENRY C., Museum of Comparative Zoology, Cambridge, Mass.
*STEWART, GRACE A., Dept. of Geology, Ohio State University, Columbus, Ohio.
STEWART, RALPH B., 405 U. S. National Museum, Washington, D. C.
*STOCK, CHESTER, California Institute of Technology, Pasadena, Calif.
*STOCKDALE, PARIS B., Ohio State University, Columbus, Ohio.
STOKES, WILLIAM LEE, Princeton University, Princeton, N. J.
STONER, REGINALD C., Standard Oil Building, San Francisco, Calif.
STOUT, THOMPSON MYLAN, University of Nebraska State Museum, Lincoln, Neb.
STOVALL, JOHN WILLIS, University of Oklahoma, Norman, Okla.
*STOYANOW, ALEXANDER, University of Arizona, Tucson, Ariz.
STUMM, ERWIN CHARLES, Dept. of Geology, Oberlin College, Oberlin, Ohio.
STURGEON, MYRON THOMAS, Michigan State Normal School, Ypsilanti, Mich.
SUMMERSON, CHARLES H., Dept. of Geology, University of Illinois, Urbana, Ill.
*SUTTON, A. H., Dept. of Geology, University of Illinois, Urbana, Ill.
SWANN, DAVID HENRY, Brown University, Providence, R. I.
*SWARTZ, CHARLES K., Johns Hopkins University, Baltimore, Md.
*SWARTZ, FRANK M., Pennsylvania State College, State College, Pa.

*TALBOT, MIGNON, Mount Holyoke College, South Hadley, Mass.
TAPPAN, HELEN NINA, 452 College Ave., Norman, Okla.
TAYLOR, DAVID, Dept. of Paleontology, Univ. of California, Berkeley, Calif.
TEICHERT, CURT, University of Western Australia, Crawley, Western Australia.
TEN EYCK, RICHARD GUERT, 342 Columbia Ave., Pomona, Calif.
THOMAS, HORACE D., University of Wyoming, Laramie, Wyo.
THOMAS, NORMAN LOUIS, P. O. Box 38, Bakersfield, Calif.
THOMPSON, MARCUS LUTHER, New Mexico School of Mines, Socorro, N. M.
TIEJE, ARTHUR J., Cordova Hotel, Los Angeles, Calif.
TOEPELMANN, WALTER C., University of Colorado, Boulder, Colo.
*TOLMACHOFF, I. P., Carnegie Museum, Pittsburgh, Pa.
TOULMIN, LYMAN D., JR., Dept. of Geology, Texas A. & M. College, College Station, Tex.
TROMP, S. W., Socony-Vacuum Oil Company, Sharia Ibrahim Pasha, Cairo, Egypt.
*TROXELL, EDWARD L., Trinity College, Hartford, Conn.
*TURNER, F. E., Texas Agricultural and Mechanical College, College Station, Tex.
*TWENHOFEL, WILLIAM H., University of Wisconsin, Madison, Wis.

*ULRICH, EDWARD O., U. S. National Museum, Washington, D. C.

VAN HOUTEN, FRANKLYN B., Dept. of Geology, Williams College, Williamstown, Mass.
*VAN TUYL, FRANCIS M., Colorado School of Mines, Golden, Colo.
*VAUGHAN, T. WAYLAND, 3333 P St., NW., Washington, D. C.
VESTAL, FRANKLIN E., Dept. of Geology, Rosenwald Hall, University of Chicago, Chicago, Ill.
*VOKES, HAROLD E., American Museum of Natural History, New York, N. Y.

WAAGÉ, KARL M., Dept. of Geology, Princeton University, Princeton, N. J.
WALTER, H. GLENN, Drawer FF, Hobbs, N. M.
*WANLESS, HAROLD R., 241 Natural History Bldg., University of Illinois, Urbana, Ill.
WARD, FRANK HAWLEY, P. O. Box 24, Beechwood Station, Rochester, N. Y.
WARNER, WILLIAM C., Box 416, Nowata, Okla.
*WARREN, PERCIVAL S., University of Alberta, Edmonton, Alta., Canada.

WARTHIN, ALDRED SCOTT, JR., Vassar College, Poughkeepsie, N. Y.
*WELLER, J. MARVIN, State Geological Survey of Illinois, Urbana, Ill.
WELLES, SAMUEL PAUL, Museum of Paleontology, University of California, Berkeley, Calif.
WELLS, DANA, 633 Spruce St., Morgantown, W. Va.
WELLS, JOHN WEST, Dept. of Geology, Ohio State University, Columbus, Ohio.
WERNER, COURTNEY, Dept. of Geology, Washington University, St. Louis, Mo.
*WESTGATE, LEWIS G., Ohio Wesleyan University, Delaware, Ohio.
*WETMORE, ALEXANDER, U. S. National Museum, Washington, D. C.
WHEELER, HARRY EUGENE, Mackay School of Mines, University of Nevada, Reno, Nev.
WHIPPLE, G. Leslie, 1215 Atlantic Ave., Long Beach, Calif.
*WHITCOMB, LAWRENCE, Dept. of Geology, Lehigh University, Bethlehem, Pa.
WHITE, THEODORE E., Museum of Comparative Zoology, Cambridge, Mass.
WHITMORE, FRANK C., JR., 72 Kirkland Street, Cambridge, Mass.
*WHITNEY, F. L., University of Texas, Austin, Tex.
WICKENDEN, ROBERT THOMAS DAUBIGNY, Geological Survey of Canada, Ottawa, Canada.
WILDER, BEVERLY B., Dept. of Paleontology, Univ. of California, Berkeley, Calif.
*WILLARD, BRADFORD, Dept. of Geology, Lehigh University, Bethlehem, Pa.
*WILLIAMS, JAMES STEELE, U. S. Geological Survey, Washington, D. C.
WILLIAMS, JAMES STEWART, Dept. of Geology, Utah Agricultural College, Logan, Utah.
*WILLIAMS, MERTON Y., University of British Columbia, Vancouver, B. C., Canada.
*WILSON, ALICE E., Victoria Memorial Museum, Ottawa, Ont., Canada.
*WILSON, C. W., JR., Dept. of Geology, Vanderbilt University, Nashville, Tenn.
WILSON, LESLIE E., 215 7th Ave., San Mateo, Calif.
WILSON, ROBERT WARREN, Dept. of Geology, University of Colorado, Boulder, Colo.
WINTON, W. M., Texas Christian University, Fort Worth, Tex.
*WOOD, ALBERT ELMER, 8 Lathrop Ave., Binghamton, N. Y.
*WOOD, HORACE E., II, Dept. of Biology, University of Newark, Rector St., Newark, N. J.
*WOODRING, WENDELL P., U. S. Geological Survey, Washington, D. C.

YOUNG, FREDERICK PENTZ, JR., 506 West 122d St., New York, N. Y.
YOUNG, JOHN A., JR., Dept. of Geology, Michigan State College, East Lansing, Mich.

CORRESPONDENTS DECEASED

BATHER, DR. F. A. Died Mar. 20, 1934.
BUCKMAN, S. S. Died Feb. 26, 1929.
CANU, FERDINAND. Died Feb. 12, 1932.
COBBOLD, EDGAR STERLING. Died Nov. 20, 1936.
DEPÉRET, PROF. CHARLES. Died May 17, 1929.
KAIER, PROF. JOHAN. Died Oct. 31, 1931.
KOKEN, E. Died Nov. 24, 1912.
KOLINA, DR. JAN. Died April 7, 1939.
NATHORST, DR. A. C. Died Jan. 20, 1921.
POMPECKI, DR. J. F. Died July 8, 1930.
STEFANINI, PROF. G. Died Sept. 15, 1938.
WOODWARD, DR. H. Died Sept. 6, 1921.

MEMBERS AND FELLOWS DECEASED

*ALDRICH, TRUMAN H. Died Apr. 28, 1932.
*AMI, HENRY M. Died Jan. 4, 1931.
ARMSTRONG, EDWIN J. Died Jan. 21, 1929.
*BARRELL, JOSEPH. Died May 4, 1919.
BEEDE, JOSHUA W. Died Feb. 27, 1940.
BELANSKI, CHARLES H. Died Apr. 30, 1929.
BENSLEY, B. A. Died Jan. 20, 1934.
BILLINGS, W. R. Died Mar. 1, 1920
BOSTWICH, THOMAS A. Died Apr. 1923.
*BROWN, T. C. Died Feb. 28, 1934.
*CALVIN, SAMUEL. Died Apr. 17, 1911.
*CLARK, WM. B. Died July 27, 1917.
*CLARKE, JOHN M. Died May 29, 1925.
*CLELAND, HERDMAN F. Died Jan. 24, 1935.
*CROOK, A. R. Died May 30, 1930.
CROZEL, GEORGE. Died Oct., 1921.
DALL, W. H. Died Mar. 27, 1927.
*DEAN, BASHFORD. Died Dec. 6, 1928.
*DERBY, ORVILLE A. Died Nov. 27, 1915.
DOUGLASS, EARL. Died Jan. 13, 1931.
*EASTMAN, CHAS. R. Died Sept. 27, 1918.
*FOERSTE, AUGUST F. Died Apr. 23, 1936.
*FONTAINE, WM. M. Died Apr. 30, 1913.
GIBB, HUGH. Died Feb. 28, 1932.
*GIDLEY, JAMES WM. Died Sept. 26, 1931.
GILL, THEODORE N. Died Sept. 25, 1914.
GIRTY, GEORGE HERBERT. Died Jan. 27, 1939.
GORDON, ROBERT H. Died May 10, 1910.
GRAHAM, ROY. Died Aug. 9, 1939.
HAMLIN, HOMER. Died July, 1920.

HARPER, GEORGE W. Died Aug. 19, 1918.
HAWYER, J. C. Died May 15, 1914.
*HAY, O. P. Died Nov. 2, 1930.
*HENDERSON, JUNIUS. Died Nov. 4, 1937.
HOLLAND, WM. J. Died Dec. 15, 1932.
HOLLICK, ARTHUR. Died Mar. 16, 1933.
HOLMES, WALTER W. Died Nov. 13, 1938.
*HUDSON, GEORGE H. Died Mar. 19, 1934.
*HYDE, JESSE E. Died July 3, 1936.
JOHNSTON, C. STUART. Died July 23, 1939.
*KEYTE, I. A. Died May 29, 1931.
KINDLE, EDWARD M. Died Aug. 29, 1940.
*KNOWLTON, FRANK H. Died Nov. 21, 1926.
*LAMBE, L. M. Died Mar. 12, 1919.
LEE, WILLIS T. Died June 17, 1926.
*LOOMIS, FREDERICK B. Died July 28, 1937.
LUSK, RALPH G. Died July 27, 1927.
LUTHER, D. D. Died Dec. 17, 1923.
LYON, VICTOR W. Died Aug. 17, 1919.
MACBRIDE, THOMAS H. Died Mar. 27, 1934.
*MANSFIELD, WENDELL C. Died July 24, 1939.
MARTIN, BRUCE. Died Dec. 23, 1919.
MARTIN, HANDELL T. Died Jan. 15, 1931.
MATTHEW, GEO. F. Died Apr. 17, 1923.
*MATTHEW, W. D. Died Sept. 24, 1930.
MEACHEM, R. P. Died Feb. 13, 1934.
MOODY, W. L. Died Oct. 9, 1930.
NOBLE, G. KINGSLEY. Died Dec. 9, 1940.
*NOÉ, ADOLF C. Died Apr. 10, 1939.
*PARKS, WM. A. Died Oct. 3, 1936.
PATTEN, WM. Died Oct. 23, 1932.
PETERSON, O. A. Died Nov. 13, 1933.
*PROSSER, C. S. Died Sept. 11, 1916.
ROUNDY, PAUL V. Died June 21, 1937.
*SEELY, HENRY M. Died May 4, 1917.
*SINCLAIR, W. J. Died Mar. 25, 1935.
SLOCUM, ARTHUR W. Died Nov. 20, 1937.
*SPRINGER, FRANK. Died Sept. 22, 1927.
TEGLAND, NELLIE M. Died Dec. 1930.
TELLER, EDGAR E. Died July 19, 1923.
*THOMAS, A. O. Died Jan. 13, 1931.
*TILTON, J. L. Died Nov. 17, 1930.
*TWITCHELL, G. B. Died Apr. 28, 1933.
*TWITCHELL, M. W. Died Apr. 8, 1927.
*VAN INGEN, GILBERT. Died July 7, 1925.
*VODGES, ANTHONY W. Died Feb. 8, 1923.
*WALCOTT, CHARLES D. Died Feb. 9, 1927.
*WARING, CHARLES A. Died Nov. 5, 1918.
*WEINZIERL, MRS. J. F. Died Sept. 28, 1928.
*WELLER, STUART. Died Aug. 5, 1927.
*WHITE, DAVID. Died Feb. 7, 1935.
*WILLIAMS, HENRY S. Died July 31, 1918.
WILLISTON, S. W. Died Aug. 30, 1918.
WILSON, HERRICK E. Died Jan. 24, 1925.
WHITTAKER, EDW. Died Sept. 14, 1924.

NOMINATIONS FOR OFFICES IN THE PALEONTOLOGICAL SOCIETY FOR 1942

In accordance with the provisions of Chapter IV, Section 1, of the By-Laws, the Council of the Paleontological Society announces the following nominations for offices in the Society for 1942:

For President, E. H. Sellards, Austin, Tex.
For Vice-President, A. K. Miller, Iowa City, Iowa.
For Secretary, H. E. Vokes, New York, N. Y.
For Treasurer, Robert R. Shrock, Cambridge, Mass.
For Editor, C. Wythe Cooke, Washington, D. C.

Verlag von Gebrüder Borntraeger in Berlin W 35 Deutschland

Fortschritte der Paläontologie. prepared under direction of O. H. Schindewolf, Berlin, with aid of numerous specialists. Vol. 1—Review of the years 1935-1936, contains 384 pp., 2 figs. Price, RM 29.60; Vol. 2—Review of the years 1937-1938, contains 402 pp. Price, RM 31.20.

Fortschritte der Paläontologie **is intended to be a biennial publication indicating significant advances in paleozoology and paleobotany by means of critical summaries and discussion of the most important works issued in successive two-year periods. The first two volumes, now available, cover literature of 1935 to 1938, and provide a comprehensive view of the present status of paleontological research.**

Paläontologie, Entwicklungs- und Vererbungslehre (Paleontology, Evolutionism and Genetics) by O. H. Schindewolf; contains 108 pages, 34 text figures; published 1936. Price, RM 5.20.

This volume develops from paleontological observations and theoretical considerations a new orientation of studies on evolution. Critical inquiry on questions of evolutionary factors and a refutation of Lamarckian theories leads to accommodation of previously divergent views on evolution and heredity.

Detailed descriptions and prospectuses free

BACK VOLUMES AT HALF PRICE

Members and associate members of the Society of Economic Paleontologists and Mineralogists and of the Paleontological Society and subscribers of the

JOURNAL OF PALEONTOLOGY

will be privileged for a limited time to purchase complete Volumes 2 (1928) to 11 (1937) at the very special price of Three Dollars ($3.00) per volume. This offer represents a 50 per cent discount from regular prices and gives opportunity that should not be overlooked. Furthermore, only part of the supply of back volumes will be sold at this price. The stock of Volume 1 is exhausted, but any others can be purchased. Place order promptly if you wish to secure discount because this offer will be withdrawn as soon as allotment of copies is exhausted.

Members and associate members of the Society of Economic Paleontologists and Mineralogists and subscribers of the

JOURNAL OF SEDIMENTARY PETROLOGY

may purchase, for a limited time, complete Volumes 1 (1931) to 7 (1937), at half price, One Dollar and a Half ($1.50) per volume.

SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS
Box 979, Tulsa, Oklahoma

A National Research Council—A.A.P.G. Book

RECENT MARINE SEDIMENTS

PARKER D. TRASK, *Editor, U. S. Geological Survey, Washington, D.C.*

A SYMPOSIUM OF 34 PAPERS BY 31 AUTHORS

Prepared under the direction of a Subcommittee of the Committee on Sedimentation of the Division of Geology and Geography of the National Research Council, Washington, D.C.: CARL W. CORRENS, STINA GRIPENBERG, W. C. KRUMBEIN, PH. H. KUENEN, OTTO PRATJE, ROGER REVELLE, F. P. SHEPARD, H. C. STETSON, PARKER D. TRASK, CHAIRMAN.

Members of Committee on Sedimentation:

ELIOT BLACKWELDER, M. N. BRAMLETTE, CARL B. BROWN, M. I. GOLDMAN, M. M. LEIGHTON, H. B. MILNER, F. J. PETTIJOHN, R. DANA RUSSELL, F. P. SHEPARD, H. C. STETSON, W. A. TARR, A. C. TESTER, A. C. TROWBRIDGE, W. H. TWENHOFEL, T. WAYLAND VAUGHAN, C. K. WENTWORTH, PARKER D. TRASK, CHAIRMAN

This book is on the topic of Sedimentation and Environment of Deposition recently voted No. 1 in geological research of most importance to the progress of petroleum geology,—in a poll of the 3,000 A.A.P.G. members and associates, conducted by the Research Committee. Throughout the book, the basic data—observational facts—are emphasized rather than speculative inferences.

"This work on the recent marine sediments will be of great value to students of sediments, to classes concerned with studies of sediments, and to geologists concerned with mineral deposits in the sedimentary rocks, particularly the deposits of mineral fuels. The Subcommittee is to be congratulated on completion of the work."—*W. H. Twenhofel, University of Wisconsin.*

"The story of earth's immediate yesterdays is written in deposits as yet unconsolidated, or but little consolidated. Geologists are becoming increasingly aware of their importance, but have needed more well-collated information than has been readily available. This book will do much to remedy the lack."—*Science News Letter* (November 4, 1939).

"*Recent Marine Sediments* is a valuable and helpful addition to geologic literature and should serve as a useful supplement to the *Treatise on Sedimentation.*"—*Edwin D. McKee in Economic Geology* (January-February, 1940).

- **736 pages; 139 figures**
- **Bibliographies of 1,000 titles; 72 pages of author, citation, and subject index**
- **Bound in blue cloth; gold stamped; paper jacket; 6x9 inches**

PRICE: $5.00, POSTPAID

($4.00 TO A.A.P.G. MEMBERS AND ASSOCIATE MEMBERS, LIBRARIES, AND COLLEGES)

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
BOX 979, TULSA, OKLAHOMA, U.S.A.

OFFICERS OF THE SOCIETIES

SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

For the year ending April, 1942

President, H. V. Howe, University, La.

Past-President, Carrey Croneis, Chicago, Ill.

Vice-President, John R. Sandidge, San Antonio, Texas.

Past-President, Gayle Scott, Fort Worth, Texas.

Secretary-Treasurer, Henryk B. Stenzel, Austin, Texas.

Society Headquarters, 705 Wright Bldg., Tulsa, Okla.

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

For the year ending April, 1942

President, Edgar W. Owen, San Antonio, Tex.

Past-President, L. C. Snider, Austin, Texas.

Vice-President, John M. Vetter, Houston, Texas.

Secretary-Treasurer, Edward O. Markham, Tulsa, Okla.

Editor, W. A. Ver Wiebe, Wichita, Kan.

Association Headquarters. 708 Wright Bldg., Tulsa, Okla.

PALEONTOLOGICAL SOCIETY

For the year ending December, 1941

President, L. W. Stephenson, Washington, D.C.

Vice-President, H. G. Schenck, Palo Alto, Calif.

Secretary, H. E. Vokes, New York, N.Y.

Treasurer, Robert R. Shrock, Cambridge, Mass.

Editor, C. Wythe Cooke, Washington, D.C.

Councilors

C. O. Dunbar, New Haven, Conn.

R. W. Chaney, Berkeley, Calif.

C. W. Gilmore, Washington, D.C.

B. L. Clark, Berkeley, Calif.

GEOLOGICAL SOCIETY OF AMERICA

For the year ending December, 1940

President, C. P. Berkey, New York, N.Y.

Past-President, Eliot Blackwelder, Stanford University, Calif.

Vice-President, Douglas Johnson, New York, N.Y.

Vice-President, G. S. Hume, Ottawa, Canada.

Vice-President, R. C. Moore, Lawrence, Kan.

Vice-President, W. F. Foshag, Washington, D.C.

Secretary, H. R. Aldrich, New York, N.Y.

Treasurer, E. B. Mathews, Baltimore, Md.

Society Headquarters, 419 West 117th St., New York, N.Y.